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THESIS

ALTERNATIVE SALARY AUCTION MECHANISMS FOR THE NAVY: AN EXPERIMENTAL PROGRAM

by

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December 2007

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An experimental program was developed to test the impact of bidding behavior on two matching mechanisms proposed by prior research for use in the U.S. Navy's Assignment Incentive Pay (AIP) program. AIP is one compensation program used by the Navy to encourage sailors to volunteer for less desirable assignments. Unlike other compensation programs, sailors negotiate AIP rates through an auction-like system. Previous research has proposed new mechanisms to effectively match sailors to assignments based on the sailors' bids and Navy valuations. However, the two mechanisms provide different incentives for sailors to truthfully reveal their minimum acceptable AIP through their bids. The experimental program has been developed to help determine which matching mechanism gives better incentives for sailors to bid closer to their true valuations and how bidding differently than these valuations impacts the effectiveness and cost of the matching mechanisms. The proper operation of the experimental program was verified through 60 simulated sessions of ten participants bidding their true values. The program was further tested on a trial run with 20 volunteer subjects completing 20 bidding rounds each.

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ALTERNATIVE SALARY AUCTION MECHANISMS FOR THE NAVY: AN EXPERIMENTAL PROGRAM

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An experimental program was developed to test the impact of bidding behavior on two matching mechanisms proposed by prior research for use in the U.S. Navy's Assignment Incentive Pay (AIP) program. AIP is one compensation program used by the Navy to encourage sailors to volunteer for less desirable assignments. Unlike other compensation programs, sailors negotiate AIP rates through an auction-like system. Previous research has proposed new mechanisms to effectively match sailors to assignments based on the sailors' bids and Navy valuations. However, the two mechanisms provide different incentives for sailors to truthfully reveal their minimum acceptable AIP through their bids. The experimental program has been developed to help determine which matching mechanism gives better incentives for sailors to bid closer to their true valuations and how bidding differently than these valuations impacts the effectiveness and cost of the matching mechanisms. The proper operation of the experimental program was verified through 60 simulated sessions of ten participants bidding their true values. The program was further tested on a trial run with 20 volunteer subjects completing 20 bidding rounds each.

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I. INTRODUCTION

A. BACKGROUND

The Navy introduced Assignment Incentive Pay (AIP) as a cost-effective means to entice sailors to volunteer for difficult to fill billets. AIP is a relatively small program, accounting for $26 million of the approximately $900 million the Navy budgeted for special pays to enlisted personnel. AIP is an auction type system where sailors bid a monthly incentive pay amount that they would be willing to accept to volunteer for an assignment.

Traditionally, efficient incentives for these hard-to-fill billets are difficult to determine. Incentive pay levels have typically been set based on historical data about how hard a billet is to fill with a volunteer. Pay levels are raised or lowered on an infrequent basis. Other non-monetary incentives may also be used (e.g., improved advancement chances, improved choice for follow-on assignment). No attempt has been made to assess changes in assignment desirability. Therefore, the resulting incentives set for the billets may attract too many or too few volunteers for the billets available in any given assignment period.

Auctions are used as a method to determine how much individual bidders value an item or service. Auctions may be conducted live or by sealed bid. Due to the nature of information in most live auctions, bidders have an incentive to always bid up to their true value for the good or service. However, live auctions are impractical when all the bidders can not gather (in-person, online, or otherwise) simultaneously during the bidding process (e.g., stationed in different assignments, locations, and time-zones around the world). Sealed bid auctions allow bidders to make bids when not able to gather for a live auction. In a sealed bid second price auction, bidders have the dominant strategy to bid their true value for the product or service up for bidding. The bid most advantageous for the auctioneer wins the commodity (highest bid where the auctioneer is taking money, lowest bid where the auctioneer is paying money), but the bidder pays or receives the first excluded bid (i.e., the second highest or lowest bid when there is only one item being sold or purchased).

The AIP process involves sailors bidding their minimum acceptable AIP levels against available billets. Sailors may bid for multiple billets. The Navy assigns the best value sailor, based primarily on AIP bid amount. When assigned through the AIP process, sailors receive the monthly incentive pay they bid for the billet for the duration of their assignment to that billet. AIP rates can vary for individual billets, based on the preferences of the sailors up for assignment, and the implementation of the matching system.

Recent student theses (Homb, 2006; Tan, 2006) have modeled and simulated the sailor to billet matching process. They have determined that there are two major complications. Since the number of qualified sailors for a billet may be limited, bidders may have an incentive to overbid their willingness to accept if they believe they will be assigned a billet regardless of their bid. Additionally, auctions assume only bidders have preferences. Sailors may overstate their willingness to accept if additional variables are included to reflect the Navy's preferences (e.g., sailor's change of station cost, additional cost to train sailor). An alternative auction mechanism that combined elements of both auction theory and matching was proposed to overcome these complications and potentially reduce the cost of AIP to the Navy.

B. PURPOSE

This research developed and verified an experimental program to investigate bidding strategies in two matching mechanisms in an auction system. The frequency of the auction mechanism successfully finding sailor-to-assignment solutions was compared to theoretical results. Observed bid-reservation value differentials were compared to theoretical differentials to assess the potential impact of gaming on the use of the proposed mechanism.

C. SCOPE AND LIMITATIONS

1. Scope

This thesis focuses on applying auction and matching theory to incentive schemes in the U.S. Navy. It summarizes auctions and matching theory, current compensation schemes in DoD, and applicability of experiments. It describes the experiment program design in detail, and verifies the proper operation of the program. The effectiveness of the algorithms proposed by Homb and Tan (Homb, 2006; Tan, 2006) at matching sailors to billets is reviewed. Recommended experimental variations that affect the truth revealing nature of the two matching models are proposed. Preliminary observations and verification of the user interface from a trial run of the program are presented.

2. Limitations

This thesis does not make policy recommendations, nor does it fully explore all the factors that drive sailors' decisions when making bids under the AIP system. The participants in the experiment are not directly representative of the Enlisted Navy population at large. The impact of ex-post bargaining or intervention by participants in the system is not evaluated. Finally, this experiment assumes that participants can accurately assign values to billets.

D. EXPECTED BENEFITS OF STUDY

This research will provide an experimental tool to help improve knowledge and understanding of the application of auction and matching theory to assignments in DoD. It will validate previously presented models and simulation. It could be used when considering the policies covering AIP in the U.S. Navy, or other similar programs throughout the DoD.

E. ORGANIZATION OF THESIS

Applicable auction and matching theory is presented in Chapter II. Chapter III presents applications of auctions for assignment in the military. The experiment program setup and validation are covered in Chapter IV. Chapter V will summarize the thesis, provide conclusions, and make recommendations for further research.

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II. AUCTION AND MATCHING THEORY

A. BACKGROUND

Economists study the distribution of resources to improve the efficiency of that distribution (Bohm, 1973). Unless restrained by prices, the demand for resources (e.g., monetary, natural, or labor) is normally greater than the supply of those resources. Economic benefits accrue to both suppliers and consumers. Suppliers' benefits are the differences between what it costs suppliers to generate the resources and what they receive for those resources. A consumer's benefit is the difference between the value that consumer places on the resource and what he or she pays for that resource. The total economic benefit (economic surplus) is the sum of benefits to both supplier and consumer, or the difference between what it costs a supplier to generate the resource and the value the consumer receives from that resource. An economically efficient distribution of resources between suppliers and consumers is one that results in the greatest overall economic benefits for the agents involved (but not necessarily an equal or otherwise "fair" distribution of benefits between suppliers and consumers).

Competitive markets maximize economic efficiency even though buyers and seller never explicitly reveal their valuations. Competition between buyers and sellers ensures that products are supplied by the most efficient producers and sold to the buyers with the highest values. Individual agents are motivated to keep values private. Agents bargain amongst themselves to set prices for goods. In a market where all goods are the same (a commodity market), the overall market value of a good will eventually be revealed (consumers will have no incentive to purchase a commodity at a higher price when a higher priced commodity brings no additional benefit). Prices are normally established over time, through multiple transactions. Consumers continue to buy commodities being sold at a lower price than their consumer value. Sellers will continue to sell those commodities, lowering prices until they no longer can recoup the cost of producing the goods.

True commodity markets are limited. In some cases very few items are available and there is great demand for these items (e.g., individual works of art or rights to extract resources from a designated area). In some case, by signaling a higher or lower value than his or her true value, an agent may be able to gain a higher surplus but, in doing so, may also change the distribution of resources possibly resulting in a less efficient outcome.

In a thin market, where limited buyers or sellers preclude a competitive market outcome, consumers and producers must reveal their true valuations in some other way to ensure economic efficiency. Without this truthful revelation, there is no guarantee that a given distribution could not be changed to improve the overall economic surplus. Auctions provide a mechanism to allocate goods in these thin markets, where there is typically either a single seller and many buyers or a single buyer and many sellers (preventing price determination through multiple buying and selling interactions of the same good). In auctions, sellers make goods available (often at a minimum, or reservation, price) and consumers express their willingness to buy goods at prices set by various mechanisms. If buyers and sellers accurately signal their values, an economically efficient distribution of goods will occur.

Different auction mechanisms have evolved over time, and each presents different incentives for accurate signaling of valuations. Auctions are recorded in ancient times, and have been used extensively to transact valuable works of art, rare wines, and even recently, the rights to use of portions of the radio spectrum (Milgrom, 1998).

B. KEY TERMINOLOGY

1. Common Value versus Independent Private-Values

An auction where an object has the same value to all the bidders is a common value auction. An example of a common value auction would be an auction for a jar of pennies. No matter who wins the jar, the jar contains the same monetary value. In the case of common value auctions, knowing another bidder’s valuation may cause bidders to revise their value estimates. In the example of the jar of pennies, bidders estimate the amount of pennies that could be contained in the volume. Since the number of pennies in a given volume can not change, errors in estimates will only arise from differing estimates of the actual volume. Each bidder will have a different estimate of the jar's value. Assuming buyers bid symmetrically according to their individual estimates of the value of the penny jar (for example, everybody bids exactly their estimate of the value or everybody bids 90% of their estimate), the bidder with the highest estimated value will ultimately win the auction. The true value of the jar most likely lies somewhere near the middle of the range of estimates, so the highest estimated value for the jar will almost always be higher than the jar's actual value. Thus, any winning bidder in a common value auction (who did not bid significantly below his or her estimate of the value of the object) will probably have overpaid for the object. The phenomenon of winning bids exceeding true values is known as the winner's curse (Milgrom, 1989). Signaling throughout the auction, as in an English auction, may also cause bidders to increase their estimates of an object's value, if encouraged by other bidders with high value estimates.

Independent private-values arise when the true value of something being auctioned is not universal. Each bidder will have a different value for an item, which is based on personal preferences, financial considerations, and tastes. A work of art by a master, tickets to a Hannah Montana concert, dinner at Applebees, or a new iPhone are all examples of private-value goods. Each bidder places a different value on the experience of owning, using, or consuming these items. Private values are less likely to be adjusted based on signaling from other bidders. However, bids may be placed in such a way to avoid revealing private values.

Bidders have a personal value whether the object has a common or private value. A bidder's personal value for an object includes the expected common or private value and the bidder's desired profit or return from the object. For example, a bidder may expect the value of a jar of pennies to be $20, but considers counting and exchanging the pennies to be worth not less than $2 of their time. In such a case the bidder's personal value for that jar of pennies would be $18, which is the maximum that buyer's willingness to pay (WTP) for that object.

2. First-price and Second-price Auctions

In first-price auctions, the winner pays or receives what he or she bid. For example, in an art auction, the winner (highest bidder) pays the amount of his final bid. In a second-price auction, the price paid is the last bid where more than one bidder remained in competition. An example of the difference would be contractors bidding for a contract where cost was the sole factor. In either auction, the winner is the bidder submitting the lowest bid. In the first-price auction, the winner would be paid their bid, while in the second-price auction the winner would be paid the second lowest bid.

3. Forward and Reverse Auctions

Auctions may involve either the buyers or sellers changing their bids (Harden & Heyman, 2002, pp. 8-13). In forward auctions, buyers adjust their bid upwards until the objects are sold. Again, the art auction provides a good example. When bidding starts there may be more than a single interested buyer. As the bid is increased, buyers will drop out until only one buyer remains willing to pay the bid price. In a reverse auction, sellers change their bids downward. This normally occurs with a single buyer and multiple sellers (or suppliers). Parts suppliers bidding for government contracts are an example. All things being equal, the buyer in this case would select the lowest bid submitted.

4. Open and Sealed-bid Auctions

Bidding in auctions may be open or sealed. Open bid auctions provide for immediate feedback for all participants. Bidders constantly indicate their preferences while bidding is open. This may be accomplished by a live auctioneer standing in front of the room taking increasing (or decreasing) bids. It is also common on internet sites such as E-bay that show the current high bid from bidders around the world. Conversely, sealed bid auctions do not advertise bidder intentions. Bidders provide their bids to the auctioneer secretly. At the close of bidding (normally a specified time), the auctioneer reviews all the bids and then announces the winner and the final price.

5. Single and Multi-object Auctions

Auctions may be for a single object at a time, or for more than one object at the same time. The criterion for ending a single object auction is normally when the auctioneer can match a single seller with a single buyer, through ascending or descending bids.

Multi-object auctions are more complex. The auctioneer will have to match multiple objects from one or more sellers to one or more buyers. Multiple objects could be sold through multiple single object auctions, but that may cause inefficiencies for the buyer or seller. Multiple single object auctions cannot capture the effects of interdependent utility functions (Engelbrecht-Wiggans & Weber, 1979). For example, the government sells the rights to use ranges of radio frequency by auction. Typically, the total range of frequency available is broken into smaller ranges (blocks). Buyers are interested in specific ranges that may include several blocks for sale. Buyers have an expected value for that range of frequencies, but may expect that any less than the full range desired would not generate income. Such buyers would not have the same incentive to bid in single object auctions where they could not be guaranteed winning all of the desired frequency range.

6. Risk Neutrality

The expected value of an object is the product of the value of an object and the probability that an object would be obtained. Consider a lottery where the winnings could be $100 and only 100 tickets are sold. Each ticket then has a 1/100 chance of winning, so the expected value of each ticket is $1. A risk neutral person is indifferent between two choices where the expected value is the same (Davis & Holt, 1993, p. 73). A risk neutral person would be indifferent between an offer of $1 cash or a single ticket in the described lottery. A risk-averse person prefers a more certain outcome, and would prefer the $1 cash. Conversely, a risk-seeking person would choose the lottery ticket.

C. TYPES OF AUCTIONS

Single object auctions can normally be identified as one of four basic types: English, Dutch, first-price sealed-bid, and second-price sealed-bid (Klemperer, 2004, p. 11). Strategies described assume risk neutral bidders.

1. English Auction

The English Auction, also known as ascending-bid, is generally a forward type auction where bids are gradually raised until only a single bidder remains. A key component to this type of auction is its openness. Bidders have some knowledge of WTPs of other bidders by knowing when their competition ceases to bid. The bidder with the highest WTP for the auctioned object wins when they make the last (highest) uncontested bid. The added surplus (presumably WTP includes the bidders required return from the object) winners receive is the difference between their WTP and what they pay (the final bid).

The dominant strategy for all bidders is to continue bidding as long as their WTP for the object remains above the current bid (Milgrom, 1989, p. 8). If a bidder attempts to gain a higher surplus by not continuing to bid up to their WTP they will not make any gain when the object goes to another bidder. Similarly, someone bidding above their WTP will lose surplus in an attempt to ensure winning the object. Bidders also have the incentive not to increase the bid amount more than the required increment since that could result in a winning bid higher than necessary to beat the bidder with the second highest WTP.

2. Dutch Auction

The Dutch auction is characterized by bids descending from a price higher than any bidder is willing to pay. The first person to signal an acceptance of the bid price wins the object. The winner is most likely to be the bidder with the highest WTP, but that is not ensured.

Unlike the English auction, there is no dominant bidding strategy in the Dutch auction (Milgrom, 1989, p. 8). In the English auction, the winning bid is just above the

WTP for all other bidders. Bidders do not have to estimate each other's WTPs since they are signaled throughout the bidding round. In Dutch auctions, competing bidders only observe the winning bid. Bidders can only increase their surplus by extending the auction by waiting until the bid has dropped below their WTP (whereas in an English auction a buyer cannot improve their surplus by extending the auction). As bidders wait in a Dutch auction the surplus they win increases, but the probability they will win decreases. It is not possible to know how long to wait to reach the optimum bidding amount. The incentive for bidders is to allow the bid to drop to some point below their WTP, but just above what they expect all other bidders with lower WTPs to bid. This makes the Dutch auction much less truth revealing than the English auction. In addition, unless bidders have the same expectation about the distribution of WTP values, the Dutch auction is also less efficient because the object may not be won by the bidder with the highest WTP (i.e., the bidder who would receive the greatest benefit for the object being sold).

3. First-Price Sealed-Bid Auction

In sealed-bid type auctions, bids are kept secret among the bidders. Bids are opened by the auctioneer to determine the winning bid. Sealed-bid auctions may be forward or reverse type auctions (many buyers bidding or many sellers bidding), thus the winning bid may either be the highest bid (among many buyers) or the lowest bid (among many sellers). As in the Dutch auction, the incentive in a first-price sealed bid auction is for buyers to bid below their WTP and above what they expect other buyers with lower WTPs to bid. As such, it is not a truth revealing auction and may not be efficient.

4. Second-Price Sealed-Bid Auction

In a second-price sealed-bid auction the winner pays the amount of the first excluded bid. Bids are still made secretly and the winner is determined by the auctioneer. For example, if the bids for a case of wine were $110, $105, $90, and $85, the bidder making the $110 bid would win the wine at a price of $105. The auctioneer essentially takes on the role of bidders reacting to the signals of other bidders in an English auction. A second-price sealed-bid auction leads to a dominant strategy of bidding WTP. The arguments for not bidding above or below WTP are the same as for English auctions.

D. MATCHING THEORY

Auctions assume that only one side of the market (buyers or sellers) has preferences. For example, in an English auction, only buyers have preferences for objects while the seller has no preference among buyers (other than preferring the buyer making the highest bid). Additionally, auctions normally match one buyer to one seller at a time. Matching theory involves multiple buyers and sellers who both have preferences.

The most often used example is the marriage game (Roth & Sotomayor, 1990, pp. 9-30). In this theoretical game, there is a defined set of men and women. Men have an ordered preference for each of the women, and women have an ordered preference for each of the men. The preferences could also include not willing to accept a proposed match (i.e., willing to stay single rather than marry the available possibilities), or equal preference among different match possibilities. Each marriage could only be one man and one woman. A stable set of matches is one where no potential partners not matched in a marriage would both prefer one another to the partners to whom they are matched.

A mechanism for making stable marriage matches would involve multiple rounds of temporary matches. For example, each man could attempt to match himself with his highest preference. Women would reject all but the most preferred man making a proposal (and would reject any unacceptable proposed matches). Unmatched men would then match themselves to their next preferred woman. Women again would reject all but the most preferred man making a proposed match (a woman would take the best choice from either round one or two). The process would continue until all men and women are matched, or no further women remain that unmatched men would prefer to marry rather than remaining single. An alternative stable mechanism would have the roles reversed, with women proposing matches and men accepting or rejecting those matches.

The marriage example can easily be applied to a job market. Job seekers would have preferences among the available jobs, which could be expressed as the minimum salary they would be willing-to-accept (WTA) to take the job. Similarly, employers would have preferences among all the available job seekers that would be expressed as a maximum salary they are willing-to-pay (WTP) for that potential employee. The job-seeker’s surplus from any match would be the salary he receives minus his WTA for that job, while the employer’s surplus would be its WTP for that employee minus the salary paid. A stable matching mechanism would match job seekers to jobs at a salary between their WTA and the employers’ WTP. In addition, a stable matching mechanism must also have the feature that it generates no combination of employer and job seeker who are not matched to each other but for whom there is some salary at which they would both prefer to be matched to each other as opposed to the partners to whom they are matched by the mechanism. Again, the possibility would exist for some seekers or jobs to remain unmatched.

Matching mechanisms may be more beneficial to one side or the other. Consider the marriage matching mechanisms described above. While both are stable, the former mechanism in which men propose yields better outcomes for the men (it is “man optimal”) while the latter mechanism in which women propose yields better outcomes for the women (it is “woman optimal”). In particular, the former mechanism will tend to give better (more preferred) matches to men who make the proposals than women who can only accept or reject proposals (there is no guarantee that a women’s most preferred man will ever propose to her, giving her the chance to reject less preferred men). Matching mechanisms for job markets will be similarly optimized to employees or employers, depending on who makes the initial offer matching proposals. As such, a greater share of economic surplus can be expected to be earned by the side making the initial proposal.

E. CHAPTER SUMMARY

Auctions are a common mechanism to transfer objects and money between buyers and sellers. The English and second-price sealed-bid auctions are most truth revealing and efficient of the four common types. However, auctions normally assume that only buyers or sellers have preferences, and that one object at a time will be sold. Matching theory addresses cases where buyers and sellers both have preferences, and where multiple objects must be matched between buyers and sellers at the same time. Matching mechanisms tend to be optimized for one side over the other.

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III. APPLICATIONS OF AUCTIONS FOR ASSIGNMENTS IN THE MILITARY

A. INTRODUCTION

The total pay sailors receive each pay period varies based mainly on their pay grade, time in service, skill set, and assignment location. Some non-monetary incentives and sea/shore rotation management are also used. Each type of pay is used as a retention tool or incentive to take a certain billet. All pays, except Assignment Incentive Pay (AIP), are set centrally by the Navy without sailor interaction. AIP is very specific to location and skill set, and is set in conjunction with sailors through an auction matching process. The process can match sailors to billets by maximizing the economic surplus gained by either the sailors or the Navy. The method chosen will also influence how sailors may try to game the system. The method used for AIP seems to shift the surplus to the Navy, and considers more factors than the sailor's AIP bid.

B. TRADITIONAL ASSIGNMENT INCENTIVES

1. Monetary Incentives

Total compensation paid to sailors varies with many factors (e.g., sailor's pay grade and skill set, billet location). The primary source of compensation is basic pay. The amount of basic pay is determined by the sailor's pay grade and amount of time in service. There is no differentiation across job types or location and pay is consistent across the services. Sailors are also paid basic allowance for subsistence, based on pay grade, marital status, and availability of enlisted dining facilities. These two basic pays are retention oriented, rather than being assignment incentives.

Several types of pay are based on the sailor's duty location. These include basic allowance for housing, overseas housing allowance, and cost of living allowance. These allowances are common across services, and do not depend on the sailor's specialty or job type, but are variable by pay grade and marital status. These allowances are set to provide sailors comparable purchasing power regardless of location, and are not intended to entice a sailor to one location over another. Some locations may also qualify as a tax free exclusion zone (for enlisted personnel, no pay is subject to federal income tax while stationed in the zone), while some other locations qualify for hardship duty pay. Sailors may also qualify for overseas extension pay. Career sea pay also depends on location (specifically, assigned to a sea-going billet). These latter location specific pays are intended to entice one location choice over another.

Some compensation schemes target specific skill sets. Selective reenlistment bonus (SRB) rates depend on the sailor's specialty and time in service. Sailors must accept follow-on assignment to be eligible for SRB, but the SRB amount does not vary by location.

The final type of monetary compensation varies by location, job type, pay grade, and skill set. Special Operations Command assignment incentive pay is an example, as is special duty assignment pay. These special pays are set by the Navy without direct negotiation with sailors (Command, 2007). The rates are based on historical data, and attempt to attract volunteers with specific qualifications to billets in specific locations by sailor skill set (each billet with similar requirements is entitled to the same pay). AIP differs from all the other pay schemes in that the sailor negotiates (through an auction mechanism) the amount of pay with the Navy. Consequently two similarly skilled sailors in similar billets may be paid differently.

2. Non-monetary Compensations

The Navy employs a number of non-monetary compensation schemes as well. Programs include quality of life issues, such as low cost recreation programs and health care, education opportunities or other programs generically designed to retain sailors. More specifically targeted programs include improved choices for follow on assignment, improved advancement opportunities, and managing sea/shore rotation.

Most shore duty assignments are considered desirable (i.e., sufficient numbers of sailors volunteer for the assignment). Some of these billets could be filled by civilians, but the Navy fills them with sailors to ensure there are enough non-sea going billets available for sailors. Other shore duty assignments are of a type that must be filled by sailors. Not all of these latter assignments are desirable.

The Navy manages filling sea billets primarily by setting sea/shore rotation requirements by sailor specialty. For example, an aviation electrician may be required to fill a sea going billet 48 months for every 30 months they fill a non-sea going billet. Excessive sea time affects retention, so managing sea/shore rotation is a retention issue. Studies have shown career sea pay is also effective at raising retention rates (H. L. W. Golding & Gregory, 2001). The Navy also gives sea duty credit (but not sea pay) for certain critical shore billets that have proven difficult to fill. These billets are less desirable than other shore billets, but more desirable than sea going billets. This has the effect of decreasing sailor's at sea time (raising retention) and increasing the volunteer rate for those hard to fill billets.

The Center for Naval Analyses estimates giving sea duty credit as an enticement for undesirable shore billets costs the Navy $83 million to $195 million per year in excess end strength costs (Golfin, Lien, & Gregory, 2004). These billets require higher end strength because they count against the sea portion of the sea/shore rotation, establishing the need for more shore billets coded as shore billets, driving up the required end strength number. The savings projected assume that all sea duty coded shore billets are converted to shore duty coded billets on the AIP system, and excess shore billets are outsourced.

In some cases, sailors must be assigned to billets involuntarily. This increases the chances that the sailor will leave the Navy, resulting in additional recruiting and training costs. Sailors involuntarily assigned to billets will receive all current compensations for that billet except AIP[1].

C. AUCTION MECHANISM CONSIDERATIONS FOR ASSIGNMENTS IN THE NAVY

The Navy must choose an auction format and design to implement the AIP program based on the Navy's preferences for economic efficiency, cost effectiveness, equity, and practicality (Homb, 2006; Tan, 2006). Stokey and Zeckhauser's (1978) rule for economic efficiency is "in any choice situation, select the alternative that produces the

[1] All pays and allowances, except AIP, are like government entitlements: they are paid automatically to each qualifying sailor.

greatest net benefit" for all parties. Net benefit, or economic surplus, is the difference between how much a sailor is paid to fill a billet (all pays including AIP) minus the minimum he would be willing to accept to fill the billet, plus the difference between the value the Navy places on the services of that sailor in the billet and the total amount of compensation paid (all pays including AIP). The sailor will receive benefit from the AIP system only if he is chosen for an AIP assignment. Note that, if all sailors were equally qualified for a billet, the Navy would realize the greatest benefit from choosing the lowest cost sailor (lowest bid and transfer cost combination).

As a baseline, suppose that (1) cost were the only consideration in filling billets, (2) there were significantly more sailors competing for billets than there were AIP billets available, and (3) there was minimal chance that the same sailor would be the low cost sailor (lowest bid and transfer cost) for more than one billet. Under these extreme conditions, either the English or sealed bid second price auction formats theoretically will ensure sailors bid closest to their true values. Cost effectiveness suggests that priority should be given to distributing surplus value to the Navy. All the auction formats theoretically produce the same surplus given risk-neutral sailors bidding. If sailors are risk averse[2], however, Dutch and first-price sealed-bid auctions transfer the most surplus value to the Navy.

Equity is fairness among sailors, and may mean equal pay or equal benefit (surplus)[3]. No auction format would result in equal AIP awards across all sailors in all locations. That inequity is by design; rather, the goal is for equal benefit across locations. Since Dutch and sealed-bid first-price auctions will result in less variation in sailor surplus (the difference between AIP paid and the reservation values), they both provide more equal benefit among sailors.

Finally, regardless of efficiency, effectiveness, or equity preferences, the format chosen must be practical to implement. Both English and Dutch auctions would require conducting the auction at the same time for all participants. Since sailors are deployed

[2] For example, sailors adjust bids to increase chance of winning billet because increased competition or other factors reduce the chance of winning a desired billet,

[3] Surplus is the difference between sailor's reservation price and they bid.

throughout the world, working inflexible shifts or critical, time-dependent tasks, it would be impractical to conduct the auction at the same time (even with the use of the internet or video conferencing). Sealed bid auctions allow bids to be made at anytime (within a bidding window), and may be done when a sailor has the time.

Thus, if traditional auctions were the only mechanisms under consideration, the choice would then become whether to use first or second price auctions. First price auctions are preferred when considering effectiveness and equity, while second price is preferred when considering efficiency.

D. COMPLICATIONS WITH USE OF AUCTIONS FOR ASSIGNMENTS IN THE NAVY

Auction theory normally assumes that sellers have no preference for one buyer over another, only a preference to maximize their own surplus. Since the Navy does have preferences for some sailors over others, the potential for gaming the system (not bidding their true value) exists with AIP. The Center for Naval Analyses discusses six scenarios of gaming (H. L. Golding & Cox, 2003).

There are three conditions that may lead to sailors bidding higher than their true value: little perceived weight of the AIP bid in selecting the sailor; desirable non-AIP billets available; and low competition for specific billets. A perceived high risk of being involuntarily assigned to another more undesirable billet will likely cause a sailor to bid a low amount for an AIP billet that is also not desired ("the lesser of two evils")[4]. The amount of knowledge that sailors may have about what the competition is bidding for a desired billet may also lead sailors to not bid their true value.

Sailors could raise the overall level of AIP paid if they all colluded to bid high. However, the risk of this kind of collusion among applicants is assessed to be low since AIP cycles are relatively short and sailors bidding have no easy way of communicating among themselves. Collusion would require knowing who else is in the detailing window, who desires the same assignment, and how to contact them. These sailors are

[4] While this may save the Navy money in the short term, it may adversely affect that sailor's retention decision.

generally geographically dispersed, with some on deployment or away from base on training for deployment, home based throughout the country, and probably working different shifts.

Homb (2006) suggests that sailors have an incentive to overbid their WTA when they know there is limited competition for a billet, and the Navy will be forced to assign someone to that billet (these billets, by definition are hard to fill and essential to the Navy). Another complication arises from the two sided nature of the detailing process. The Navy is not just concerned with finding the minimum AIP amount (a one sided scenario), but is also concerned with the quality of fit of the sailor (e.g., cost to move, required en-route training, experience). Sailors may tend to overbid when they are a high quality fit for a billet For example, previous laboratory simulations of the current AIP system showed that sailors would increase their bids by about 6% for every 10% increase in their perceived qualifications, even if their true reservation wage or willingness-to-accept were unchanged (Coughlan and Gates, presentation to the Annual Navy Workforce Research and Analysis Conference, May 2, 2007, Arlington, VA). Both of these situations not only could significantly increase the cost of the AIP system but could also impact the ability of the Navy to assign a quality fit sailor to a billet if the bid that sailor put in was above the Navy's WTP for that sailor, or the bid in comparison to other sailors' bids and qualities led to a lower quality choice for a billet than was necessary.

E. AUCTION MECHANISMS

Homb (2006) proposed a mechanism combining two sided matching theory and auction theory based on work by Roth and Sotomayor (1990). The mechanism is similar to a sealed bid second price auction employing two sided matching theory. Homb's proposal allows candidates to bid only for jobs for which they are qualified. Next, reservation prices (caps) are set for each job, following which the candidates make their bids. The auctioneer sets the payment level at the cap for each job, and matches candidates to jobs based on candidate surplus. Where multiple candidates match a single job, payment levels are lowered and candidates are again matched by surplus. This process is repeated until there are one-to-one matches for bidders and jobs. Tan (2006) modified this mechanism by allowing the starting salary for a billet to vary by sailor. Tan termed this mechanism the sailor-optimal model, and also proposed a variation. Her billet-optimal model alternative made matches based on best surplus accruing to the employer from all the filled jobs.

F. CURRENT ASSIGNMENT PROCESS

Local commanders have some say in which sailors are assigned to their command. Sailors state their billet preferences online through the Career Management System (CMS, formerly JASS). CMS allows sailors to view billets available, information on how qualified they are for the billet, and information on costs the Navy will incur to transfer them to the new billet. CMS also indicates the compensation associated with the billet, and is the method that sailors bid for AIP if it is applicable to the billet. Commands then review the various applicants for their billets and enter their preferences for sailors into CMS. Finally, the detailers match sailors to billets. Where there is competition for an AIP billet, the sailor with the lower bid will normally be assigned, but costs associated with transfer and en route training will also be considered. Difficulties arise when detailers cannot match command and sailor preferences. Based on priorities, some billets may go unfilled, and some sailors may be involuntarily assigned to high priority billets.

Each command has a set billet structure. That structure is set centrally to best enable the command to achieve its mission balanced against the overall availability of sailors. It does not react to changing mission requirements levied on the command, nor are the actual abilities of sailors assigned to a command considered. As a result, where one command may have the same billets open as another command at the same location, they may not place the same priority on filling these billets. AIP currently assigns the same priority to all similar jobs in the same area.

G. CHAPTER SUMMARY

This chapter put AIP in context with the other pays a sailor may receive, either for general retention, or to encourage specific skill sets or location choice. AIP is unique in that it is the only pay negotiated with sailors (through a sealed-bid auction matching mechanism). There are two new proposed generic methods for matching sailors to AIP billets, differing by whether matches are made according to sailor or Navy surplus. Currently, the assignment process is done online, and involves the sailors, gaining commands, and the Navy assignment personnel.

IV. EXPERIMENTAL EVALUATION OF THE AUCTION MECHANISMS

A. PREVIOUS SIMULATION RESULTS

Tan (2006) simulated the two matching algorithms on Excel spreadsheets generating random numbers for willingness-to-accept (WTA) and willingness-to-pay (WTP). Tan presents the results for simulating the matching algorithms under five general categories: 1. Overall system performance, 2. Sailor value measures, 3. Billet value measures, 4. Cost measures, and 5. Quality measures. Averages are presented to two decimal points, and the range of values is presented below the average, indicated by []. Results are from 1,000 trials of the algorithms.

1. Overall System Performance

Table 1 presents the overall system performance measures for the two algorithms. "Solutions?" indicate whether the algorithm found a solution within 200 iterations of the matching loop. "Rounds" is the number of iterations of the matching loop required to obtain a solution. A solution matches no more than one sailor to each billet and each sailor to no more than one billet. "% of Sailors Assigned" and "% of Billets Filled" measure the quality of the solutions found. Where the number of billets available equals number of sailors bidding, these two percentages will be the same. Finally, "Ave Total Surplus/UB" compares the difference between WTP and WTA (the average of the total surplus across all matches) to the maximum WTP (UB).

The results show that the algorithm clearly works (finding at least one match) all the time, and usually finds a full set of matches between sailors and billets. The simulation indicated that the average total monthly economic surplus gained by sailors and billets was 57% of the maximum possible surplus range, meaning on average sailors and billets gained $1,140 economic benefit each bidding period[5].

[5] The simulation was based on the range of possible AIP values being $0 to $2,000. Currently the maximum AIP allowed by the Navy for any billet is $1,700. The equivalent economic benefic would then be $970.

Table 1. Overall System Performance Measures (from Tan, 2006)

Overall System Performance Measures	Models	
	Sailor-Optimal	Billet-Optimal
Solution?	100.00% [-]	100.00% [-]
Rounds	38 [3,132]	37 [1,140]
% of Sailors Assigned	95.78% [70.00%, 100.00%]	95.67% [70.00%, 100.00%]
% of Billets Filled	95.78% [70.00%, 100.00%]	95.67% [70.00%, 100.00%]
Ave Total Surplus/UB	56.58% [38.61, 78.33%]	56.65% [38.61%, 78.33%]

2. Sailor Value and Billet Value Measures

Table 2 presents the value measures from the sailor point of view. As above, average total surplus is the average of WTP minus WTA for each match in each matching period. Average sailor surplus is the average of the AIP minus WTA for each match in each matching period. The average AIP is the average AIP value for matched sailors. Table 3 shows the similar results from the billet point of view. In this case, billet surplus is WTP minus AIP level. An economic surplus in favor of the sailor indicates that sailors would be paid more money than required to compensate them for that billet, while an economic surplus in favor of the billet indicates that the billet gains more value from the sailor than it pays. Since no match can be made above a billet's (or below a sailor's) value, the worst a sailor or billet can do is break even.

Tan's simulations demonstrated that three-quarters of the economic surplus accrues to the sailor under the sailor-optimal method, while the opposite is true under the billet-optimal method. This equates to $820 surplus accruing to the sailor, and $280 accruing to the billet, under the sailor-optimal method. Once again, those values are reversed for billet-optimal method. On average, 65% of the total AIP amounts paid provide sailor surplus (value above the minimum acceptable amounts) under sailor-optimal method, while only 38% of total AIP generates sailor surplus under the billet-optimal method. Billet surplus, on the other hand, constituted 19% and 54% of the amount billets were willing-to-pay under sailor-optimal and billet optimal methods respectively.

Table 2. Sailor Value Measures (from Tan, 2006)

Sailor Value Measures	Models	
	Sailor-Optimal	Billet-Optimal
Average Sailor Surplus/ Average Total Surplus	74.29% [27.67%, 98.76%]	25.61% [0%, 66.48%]
Average Sailor Surplus/ UB	42.13% [15.83%, 67.22%]	14.42% [0%, 41.39%]
Average Sailor Surplus/ Ave AIP	65.54% [34.75%, 88.97%]	38.32% [0%, 78.83%]

Table 3. Billet Value Measures (from Tan, 2006)

Billet Value Measures	Models	
	Sailor-Optimal	Billet-Optimal
Average Billet Surplus/ Average Total Surplus	25.71% [1.24%, 72.33%]	74.39% [33.52%, 100.00%]
Average Billet Surplus/ UB	14.45% [0.75%, 44.69%]	42.23% [16.94%, 68.75%]
Average Billet Surplus/ Ave WTP	18.51% [0.89%, 54.58%]	53.80% [23.19%, 81.31%]

3. Cost and Quality Measures

Cost measures (Table 4) evaluated manpower costs that would be incurred based on the matches, while quality measures (Table 5) were concerned with quality of sailors matched to billets. The ratio of average AIP to maximum value for surplus (UB) shows that AIPs averaged 64% of maximum achievable WTA or WTP for sailor-optimal methods, and only 36% for billet-optimal method. By comparing ratios of each sailor's AIP to their WTP, it appears that the sailor is paid a significant portion his value to the billet (the sailor's quality) in the sailor-optimal method, but less than half of this value in the billet-optimal method (81% and 46% respectively for sailor- and billet-optimal methods). Both methods assign sailors well qualified for billets. Seventy-eight percent of the maximum possible quality was captured (comparing average AIP to the maximum achievable WTA or WTP), and 85% of each billet's possible quality was captured (comparing the matched sailor's WTP to max WTP for any sailor in each billet).

Since the matching process places a different value on each sailor, it is possible to show the cost of considering the value of a sailor to individual billets. Always matching to the least cost sailor can be done by setting all WTPs to the upper bound. Conversely, always matching the most qualified sailor to the billet can be done by setting all WTAs to zero. Considering sailors' value to billets increases the cost of AIP overall by 309% and 173% for the sailor- and billet- optimal methods respectively. Sailors matched by both methods reflect 91% of the value available to the billets.

Table 4. Cost Measures (from Tan, 2006)

Cost Measures	Models	
	Sailor-Optimal	Billet-Optimal
Avg AIP / UB	63.95% [35.83%, 86.25%]	36.23% [14.25%, 60.75%]
Avg (AIP / WTP)	81.49% [45.42%, 99.11%]	46.20% [18.69%, 76.81%]
Avg AIP (Current Model) / Avg AIP (Billet-Optimal, all WTPs = UB)	65.54% [34.75%, 88.97%]	38.32% [0%, 78.83%]

Table 5. Quality Measures (from Tan, 2006)

Quality Measures	Models	
	Sailor-Optimal	Billet-Optimal
Avg WTP / UB	78.40% [57.75%, 92.81%]	78.46% [59.25%, 92.81%]
Avg (WTP / Max WTP)	85.74% [65.32%, 99.35%]	85.81% [65.17%, 99.35%]
Avg WTP (current model) / Avg WTP (Sailor-Optimal Model, all WTAs =0)	90.59% [69.54%, 107.80%]	90.66% [70.75%, 107.80%]

4. Conclusions from the Simulation

The simulations demonstrated that both matching mechanisms were effective at matching qualified sailors to billets. The sailor-optimal method generated greater benefits for the sailor, and was more costly overall, than the billet-optimal method. However, both methods made about the same quality of matches. Considering only the simulations, the billet optimal method would be the more cost effective of the two methods to use. The simulation assumes sailors accurately determine and truthfully signal their WTA[6], and that the Navy accurately assigns WTP values to each sailor.

Sailors do not have an incentive to inflate their WTA values in the sailor-optimal method because the AIP amount for matched billets depends on WTP (an inflated WTA would not increase AIP, but may prevent a beneficial match). However, if sailors know they are better match for a billet, those sailors could, in some cases, increase the AIP paid under the billet-optimal method for those match by inflating their WTA. Therefore, sailors are more likely to advertise their true WTA under the sailor-optimal method. The reverse arguments can be made to show the opposite is true for billet WTP valuations (sailor-optimal is less truth revealing than billet-optimal). Tan (2006, p. 45) proposes that "it is more likely for sailors to know billet preferences than for billets to accurately guess sailor preferences." She proposes a laboratory experiment to determine if the sailor-optimal method would be sufficiently truth revealing to make the sailor-optimal method cost effective.

B. VERIFICATION OF EXPERIMENTAL PROGRAM

The experiment program developed for this research was tested by simulating 10 subjects participating in 60 rounds of bidding (30 each using the two matching mechanisms). The same performance measures that Tan (2006) calculated for the simulations were calculated for the 60 trial runs of the program (except where similar data could not be collected). Tables 6-10 show that the experimental program was nearly as efficient at making matches as the simulation, with similar surpluses being generated. All the tables include minimum, maximum and standard deviations for the values presented. The number of cycles to make matches was not measured in the experimental program, as this appears to be meaningless with the amount of computing power available. Due to the setup of the program, its matches could not be compared to linear programmed determined matches, nor could matches be re-run with WTPs set to

[6] A truthful valuation of WTA is the minimum amount of AIP that would leave the sailor satisfied working in that particular billet.

minimum and maximum ranges. From these results, it can be concluded that the experimental program implements the matching mechanism in the same way as Tan's simulation.

Table 6. Overall System Performance Measures.

Overall System Performance Measures	Models	
	Sailor-Optimal	Billet-Optimal
Solution?	100.00% (+0) [-]	100.00% (+0) [-]
% of Sailors Assigned	95.33% (-0.45%) [min 80.00%, max 100.00%, std 5.71%]	92.33% (-3.34%) [min 80.00%, max 100.00%, std 7.74%]
% of Billets Filled	95.33% (-0.45%) [min 80.00%, max 100.00%, std 5.71%]	92.33% (-3.34%) [min 80.00%, max 100.00%, std 7.74%]
Avg Total Surplus/Range	56.39% (-0.19%) [min 45.83%, max 69.50%, std 5.53%]	59.09% (+2.44%) [min 48.25%, max 69.38%, std 5.85%]

Table 7. Sailor Value Measures.

Sailor Value Measures	Models	
	Sailor-Optimal	Billet-Optimal
Average Sailor Surplus/ Average Total Surplus	72.30% (-1.99%) [min 13.96%, max 89.94%, std 15.77%]	27.34% (+1.73%) [min 6.60%, max 55.59%, std 13.01%]
Average Sailor Surplus/ Range	40.77% (-1.36) [min 7.01%, max 57.49%, std 10.07%]	16.16% (+1.74) [min 4.23%, max 30.75%, std 7.74%]
Average Sailor Surplus/ Avg AIP	65.47% (-0.07%) [min 24.17%, max 76.32%, std 10.24%]	44.00% (+5.68%) [min 12.34%, max 67.35%, std 14.83%]

Table 8. Billet Value Measures

Billet Value Measures	Models	
	Sailor-Optimal	Billet-Optimal
Average Billet Surplus/ Average Total Surplus	27.70% (+1.99%) [min 10.06%, max 86.04%, std 15.77]	72.66% (-1.73%) [min 44.41%, max 93.40%, std 13.01]
Average Billet Surplus/ Range	15.62% (+1.17%) [min 5.81%, max 43.24%, std 8.43%]	42.93% (+0.70%) [min 24.56%, max 59.78%, std 8.80%]
Average Billet Surplus/ Avg WTP	20.34% (+1.83%) [min 7.15%, max 59.84%, std 11.68%]	53.97% (+0.17%) [min 30.00%, max 83.89%, std 11.13%]

Table 9. Cost Measures.

Cost Measures	Models	
	Sailor-Optimal	Billet-Optimal
Avg AIP / Range	62.27% (-1.68%) [min 29.01%, max 77.79%, std 11.19%]	36.72% (+.49%) [min 11.48%, max 57.31%, std 9.17%]
Avg (AIP / WTP)	80.34% (-1.15%) [min 39.33%, max 92.97%, std 11.47%]	45.88% (-0.32%) [min 13.97%, max 68.98%, std 11.04%]

Table 10. Quality Measures

Quality Measures	Models	
	Sailor-Optimal	Billet-Optimal
Avg WTP / range	77.89% (-0.51%) [min 62.50%, max 88.00%, std 5.81%]	79.66% (+1.2%) [min 70.28%, max 88.89%, std 4.93%]
Avg (WTP / Max WTP)	92.25% (+6.51%) [min 86.97%, max 97.00%, std 2.54%]	93.65% (+7.84%) [min 89.61%, max 97.49%, std 2.07%]

C. EXPERIMENT SETUP

The experimental setup is for a market type experiment (Norton, 2007). Subjects are told they are managers seeking employment, and are given a list of potential jobs with information about their WTA and WTP for those jobs, and the matching mechanism to be used. The jobs are generic. Random values for WTA and WTP simulate all the factors that job seekers and hiring managers would evaluate to determine actual WTA and WTP values. Experimental subjects make their bids for the various jobs online during a set bidding period. Following the close of the bidding period, the program makes matches based on WTP and bids, and displays the employee job matches and matched salary. Participants should be paid cash at the end of the sessions based on their earned surpluses (salary matched minus WTA) from all the treatments.

1. Selection of Experiment Subjects

Navy enlisted sailors who are considering their next job assignment comprise the population that this experiment is intended to represent. To conduct the experiment at the Naval Postgraduate School (NPS), subjects may easily be drawn from the NPS student population, NPS Navy enlisted staff population, or the Navy student population at the Defense Language Institute (DLI). The subjects that would most closely match the target population would be the Navy enlisted staff at NPS. The Navy enlisted staff at NPS have generally been in the Navy for at least one prior assignment and will negotiate for a follow-on assignment from NPS. Thus they have similar experience levels to those of the target population. However, the population of the Navy staff at NPS is too small to provide sufficient test subjects.

The next most similar set of test subjects would be the Navy students at DLI. They will have less experience with the Navy assignment process, but in some cases may be negotiating for their first assignment. The Navy student population at DLI should be large enough to draw sufficient volunteer subjects for the experiment. However, the experiment sessions would need to be conducted at DLI; scheduling and logistical set-up may be more difficult than conducting the sessions at NPS. Subjects may also be drawn from the student population at NPS. These subjects are predominantly officers (from all services, including foreign militaries). They do not follow the same assignment process as Navy enlisted members, but most have been through an assignment process where they had to consider the same factors valuing potential assignments. Subjects may be drawn from other groups as well (e.g., all DLI students or students at local colleges), although similarity to the target population will decrease, or logistical problems will increase.

Although subjects will not match the population affected by AIP, the incentives they will be given reflect the same incentives sailors would have when bidding for AIP (Davis & Holt, 1993). Recent experiments conducted both inside and outside laboratory environments demonstrate the exportability of laboratory results to a more general population (Güth, Schmidt, & Sutter, 2007). The incentive the experiment subjects will have to maximize their cash payments should reflect the incentives AIP participants would have to maximize their economic surplus from their matched assignments.

Some demographic data should be collected from the experimental subjects to control for the effect motivation and experience differences may have upon the subjects' tendency to bid their true WTA. Basic data such as age and sex should be collected, as well as military or civilian employment, rank in the military, education level, and economics background. Collecting information about rank in the military will indirectly indicate the amount of experience the subject has with the assignment process, and will allow for control between the officer and enlisted assignment processes. Information about education level and economics background is important to control for possible knowledge about optimal bidding strategies.

2. Variations of Information to Provide to Subjects

Subjects are given WTA, WTP information, and make bids by an online interface. WTAs and WTPs will be uniformly, randomly, distributed across some ranges. Subjects should be arranged in the experiment location so that they can not see information from other subjects in their cohort, and other communication during the treatments should be controlled.

Total compensation paid to sailors assigned to AIP billets is a sum of the various set pays for that location and the sailor's paygrade, plus the variable amount of AIP. This results in a well defined range of possible compensation amounts. Similarly, experimental WTA and WTP will be confined to a set range analogous to a set base pay plus a variable amount. A random uniform distribution of WTAs and WTPs within set ranges will be used to simulate the randomness of factors that drive WTA and WTP. The ranges for WTA and WTP may be set differently.

The number of subjects participating as a cohort may be varied, as may the number of jobs available in each treatment. Tan's (2006) simulation involved 10 sailors competing for 10 assignments. The program was tested for these conditions.

AIP amounts the Navy is willing to pay are made available to sailors during the bidding process, consequently the information available to test subjects regarding WTP is variable. Sailors know historical amounts of AIP paid to various assignments, and the maximum amount of AIP allowable under law. Giving test subjects the range of WTP mimics the kind of historical information sailors have. Although sailors would not know exactly how much the Navy would pay for them individually, they would have some idea of where they stand in relation to other sailors qualified for the same assignment. Similarly, test subjects are not given exact WTP information, but given a ranking of where they stand relative to the other test subjects, within the cohort, for a specific job, each bidding session. In the future, specificity of WTP ranking can be varied (from more limited information like "top half" to specifically "ranked 1 of 10").

3. Factors Affecting Compensation Paid to Experiment Subjects

Research supports using monetary rewards as incentives in economic experiments to reduce irrational subject behavior (Smith & Walker, 1993). Compensation in experiments will encourage experimental subjects to make choices similar to the choices the subject population (sailors participating in the AIP program) would make. Compensation must be set high enough to influence experiment subject decisions, but not higher than the experimenters' budget will allow. Customarily, experimental subjects are guaranteed a minimum compensation that is not affected by their choices.

Monetary compensation is normally made at an exchange rate between experimental credits to cash. The experimental credits earned should be reflective of the choices being made in the experiment. In this experiment, subjects are told they are managers seeking employment; salaries will be between \$40,000 and \$80,000. Tan's simulation did not use continuous values over the range of AIPs, but used 40 increments from minimum to maximum AIP values (\$0 to \$2,000 with an increment of \$50). The equivalent increment for this experiment range is \$1,000.

Tan (2006) calculated (average sailor surplus / range) for both matching mechanisms (sailor optimal = .4213, billet optimal = .1442). Multiplying these values by the salary range will give expected surplus per round (sailor optimal = $16,856, billet optimal $5,768). The total expected surplus for the entire experiment session of 10 sailor optimal treatments and 10 billet optimal treatments is $226,240. The appropriate exchange rate is found by dividing the total expected surplus by desired payout (220,240 experiment $ / 20 real $ = 11,312). This calculated exchange rate assumes that experimental subjects will bid their WTA values, and that they bid on all available jobs. It is expected that subjects will use bidding strategies to increase their surplus, so the exchange rate may need to be adjusted upwards.

D. PROPOSED EXPERIMENTAL PARAMETERS

Various experimental parameters should be varied to measure their effects on the bidding strategies of experimental subjects. These include changing the matching mechanism, changing the amount of WTP information provided the subjects, changing the level of competition for the jobs, and possibly allowing communication during the experiment. The variations are summarized in Table 11.

1. Matching Mechanism Used

Experiment sessions should be conducted with each matching mechanism used for one-half of the treatments. It is anticipated that the sailor-optimal method will be more truth revealing than the job-optimal method. This can be confirmed by comparing the differences between bids and WTAs under each method. Multiple sessions should be conducted changing the order of method used to control for any learning effect in the successive treatments. Experimental sessions could also be conducted without disclosing the matching method used, but this would have no direct parallel to the AIP program itself.

2. Fidelity of WTP Information

Actual WTP values are not provided to sailors, and should not be provided to experiment subjects. The program is designed to give test subjects a ranking of their

WTP for each job as compared to the WTPs for the other subjects competing for each of those jobs. In the future the program will be able to display varying degrees of WTP ranking information from no ranking information to displaying absolute rank among competitors (e.g., that they rank 1 of 10, 2 of 20, 3 of 10, etc.). Displaying no ranking information would be analogous to sailors competing for an assignment where there were many possible competitors that all had comparable qualifications. Conversely, displaying absolute rank information would be analogous to a situation where all the sailors competing for an assignment know all the other competitors. In such a case, sailors would be able to measure their likely standing among their peers, but would still not know exactly how much the Navy would be willing to pay.

Changing the fidelity of WTP information may influence bids by suggesting the amount of surplus available for each job. Subjects may attempt to increase their surplus by bidding higher or lower than their true WTA.

3. Effects of Competition Level for a Job

Sailors bidding for an assignment should have an idea about how much demand there is for that particular assignment (the simple fact that it is an AIP eligible assignment currently indicates that the assignment is less than desirable, and has low competition). The normal effects of higher demand leading to higher prices (more jobs available than willing sailors) might entice a sailor to raise their bid above their true WTA for a job. This can be tested in the experiment by making more or fewer jobs available in each treatment.

4. Effects of Communication

Tan (2006) suggests that the risk of collusion among participants is low. In most cases, sailors will not know whom they may be competing against for various assignments, and likely will not be collocated with those competitors. Preventing communication during the experiment treatments, and positioning subjects such that their information cannot be shared, emulates that environment. However, with today’s prevalence of internet communications (e.g., blogs) there is the possibility of collusion among AIP participants. Some experimental treatments should attempt to measure the impact of collusion on bidding strategies by permitting some form of communications among the experiment subjects (e.g., talking or internet blog sites).

Table 11. Summary of Parameter Variations

Set-up #	Method[1]	WTP Fidelity[2]	Demand[2]	Communication
1	1	High	At	None
2	1	Medium	At	None
3	1	Low	At	None
4	1	High	Over	None
5	1	Medium	Over	None
6	1	Low	Over	None
7	1	High	Below	None
8	1	Medium	Below	None
9	1	Low	Below	None
10	2	High	At	None
11	2	Medium	At	None
12	2	Low	At	None
13	2	High	Over	None
14	2	Medium	Over	None
15	2	Low	Over	None
16	2	High	Below	None
17	2	Medium	Below	None
18	2	Low	Below	None
19	1	High	At	Limited
20	1	Medium	At	Limited
21	1	Low	At	Limited
22	1	High	Over	Limited
23	1	Medium	Over	Limited
24	1	Low	Over	Limited
25	1	High	Below	Limited
26	1	Medium	Below	Limited
27	1	Low	Below	Limited
28	2	High	At	Limited
29	2	Medium	At	Limited
30	2	Low	At	Limited
31	2	High	Over	Limited
32	2	Medium	Over	Limited
33	2	Low	Over	Limited
34	2	High	Below	Limited
35	2	Medium	Below	Limited
36	2	Low	Below	Limited

Notes:

[1] Matching mechanism. 1 = sailor optimal (seeker optimal), 2 = billet optimal (job optimal)

[2] Fidelity of WTP ranking. High = absolute rank (1 of 10, 2 of 10, etc.), medium = thirds (top third, middle third, bottom third), low = everyone the same rank

[3] Number of jobs compared to number of subjects: at = same number of jobs as subjects, over = less jobs than number of subjects, below= more jobs than number of subjects

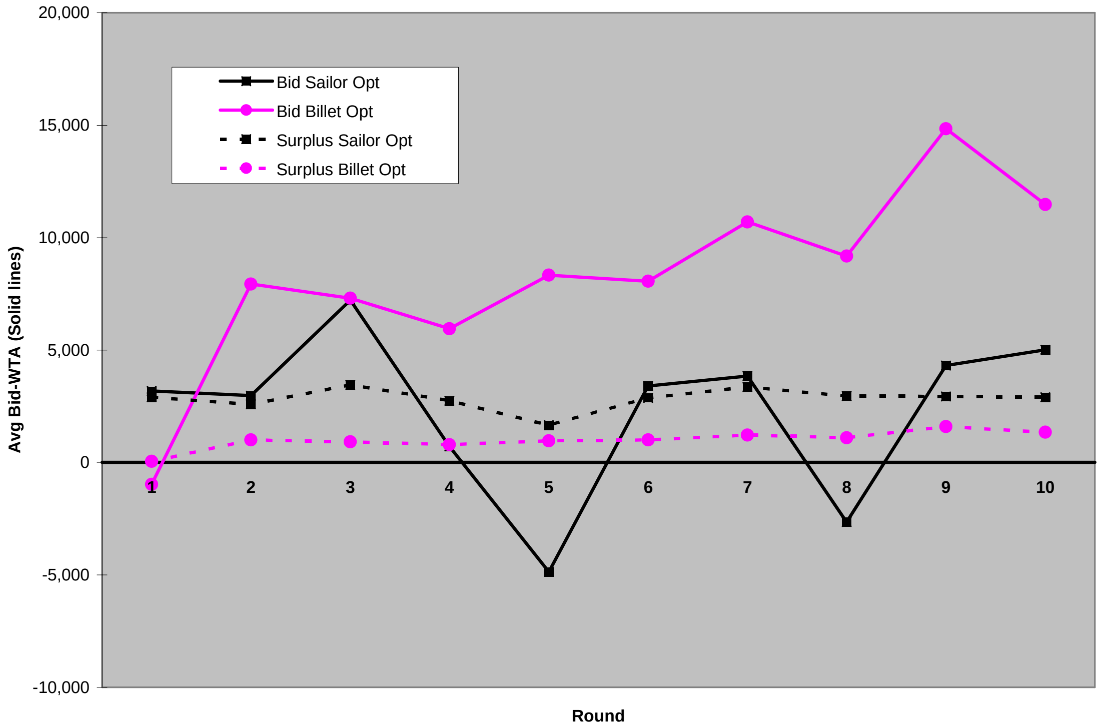
E. EXPERIMENT TRIAL RUN

A trial run of the experiment was conducted to test the program and user interface, evaluate the experiment instructions and verify the suitability of the exchange rate. Twenty students from the NPS Graduate School of Business and Public Policy (GSBPP) volunteered as experimental subjects. The trial was conducted in a GSPBB facility using the NPS standard computer configuration connected to the internet. The instructions provided to the subjects are included as Appendix A. Subjects were paid cash at the end of the experiment, ranging from $14.50 to $32.50 with $24.50 being the average (payouts were rounded up to the next $0.25). Ten bidding sessions were conducted using set-up conditions #2 and #20 (from Table 11).

1. Preliminary Observations from Trial Run

Although problems with the program affected the trial results, some preliminary observations may be made. Figure 1 shows more bids, on average, were above their WTA under the billet-optimal model (solid line with circles) than with the sailor-optimal model (solid line with squares). Figure 1 also shows the positive correlation between average bid strategy and average surplus earned (dashed lines) per round, and that subjects earned more surplus with the sailor-optimal model.

Figure 1. Bidding Strategy and Surpluses Earned by Round



The data from the trial runs strongly support the need for further experimental testing. The experimental subjects did not normally bid their WTA values (statistical analysis of variance shows bids did not equal WTA at confidence levels above 99%). Figures 2 and 3 show bidding strategies (difference between bid and WTA). Figure 2 is the frequency distribution of bidding strategy for all bids made during the trial run. For both the sailor-optimal and billet-optimal matching models, most bids were between $0 and $5,000 above the WTA amount. More bids tended to be further above WTA under the billet-optimal model than the sailor-optimal model. Figure 3 shows bidding strategies only for matches. It shows that the majority of bids making matches were below WTA. A regression of bid strategies against surpluses shows no correlation between strategies and surpluses earned for the sailor-optimal model, but a strong correlation in the billet optimal model (surplus = $1,401 + 0.9737 * (bid – WTA), adjusted R^2 = 96.0%, coefficient p-values less than 0.0001).

Figure 2. Distribution of Bidding Strategy (all bids)

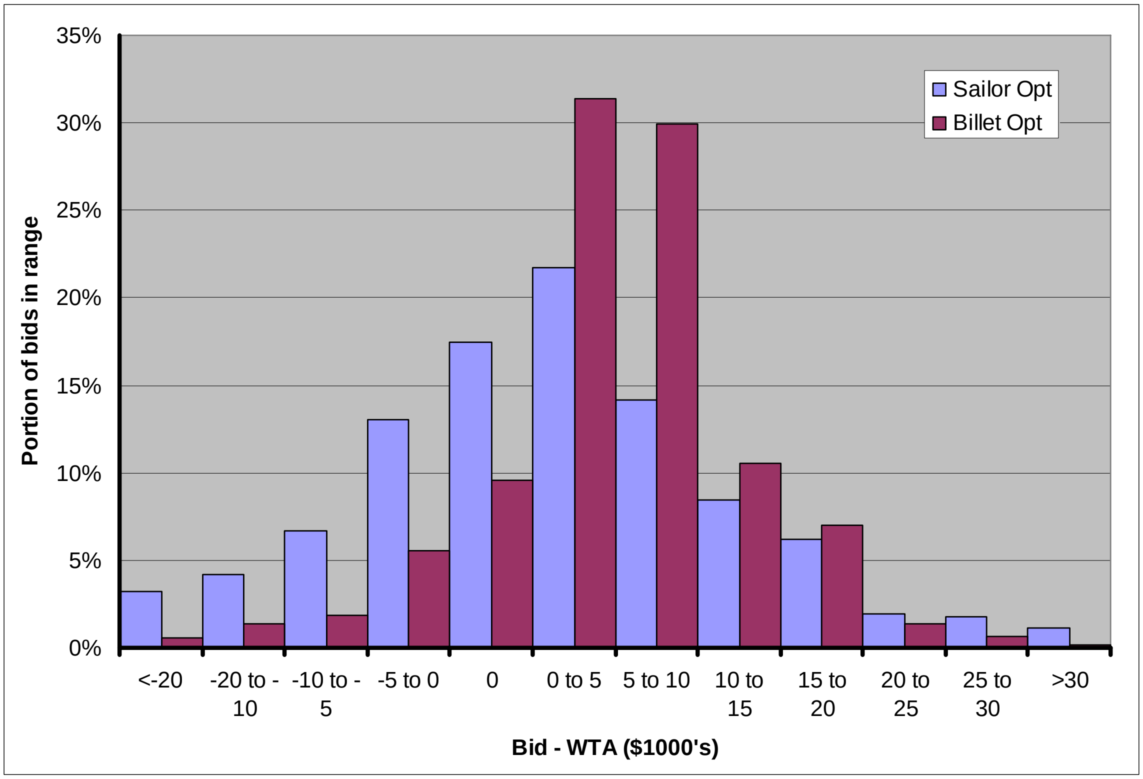
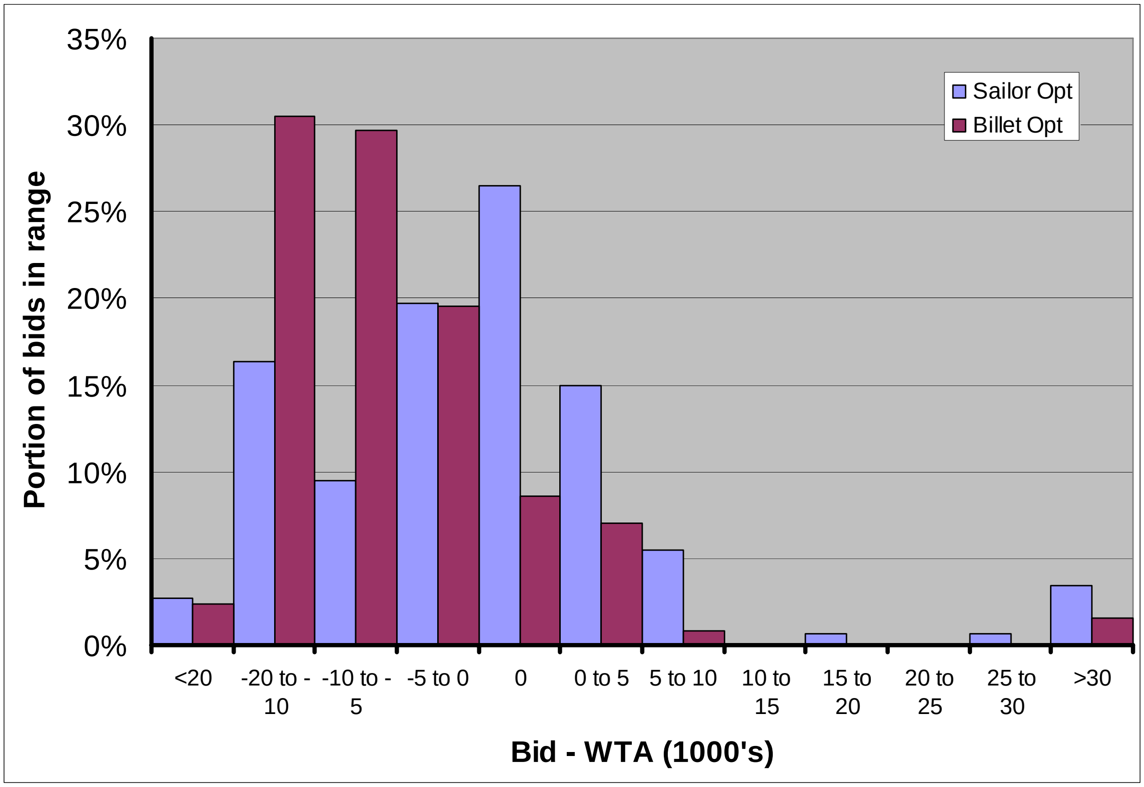


Figure 3. Distribution of Bidding Strategies (Matches Only)



2. Program and User Interface

Experiment subjects understood and were able to use the program interface without additional assistance after being read the instructions. A problem in the program's data verification routine did cause participants to fail to make bids a total of four times (out of 400 chances). The program always made a set of matches, however match rate was only 76%. This lower than predicted match rate was partially caused by four problems: the subjects' bid entries, the data verification problem[7], a low limit to matching cycles[8], and the setting for the salary increment[9]. The experiment subjects

[7] To be corrected before further experimental runs with volunteers.

[8] Matching cycles had been limited to 20 during program development for troubleshooting purposes. That restriction had not been removed prior to the trial. This restriction has been removed. The data in Paragraph B of this chapter was collected after removing this restriction.

were expected to vary their bidding strategy in an attempt to increase their earned surplus. It appears that the program interface did provide the subjects sufficient feedback to adjust their bid.

3. Experiment Instructions

The experiment instructions (script and accompanying PowerPoint slides) are included at Appendix A. They were presented in two parts: prior to starting the bidding rounds, the experiment scenario, first matching mechanism, and program interface were described to the subjects; after the first ten bidding rounds, the second matching mechanism was described. Total time to present the instructions was approximately 30 minutes.

The experimental subjects did not have any questions about the program interface; however, several questions remained about the matching mechanism processes and surplus calculation. Questions about the matching mechanisms were answered by reviewing the examples provided in the brief. Future instructions should include handouts where subjects may follow the examples in a worksheet format. That worksheet should also include surplus calculation formula, and definitions of WTA, WTP, bid and salary.

4. Exchange Rate

The calculated exchange rate for the experiment setup is $11,312 (experiment to real dollars). The actual exchange rate was rounded to $10,000 for simplicity. Targeted payout was $20 (excluding $5 participation fee); while the actual average payout was $19.50. While the exchange rate worked well for the trial, higher experimental surpluses can be expected once the program errors have been fixed and all program variables are set appropriately.

[9] As noted by Tan (2006), the salary increment should be set to less than 10% of the WTA/WTP increment. During the trial, the WTA and WTP increments were set to $1,000, and the salary step was set to $100.

F. CHAPTER SUMMARY

Simulation of both proposed matching mechanisms demonstrate their efficiency and effectiveness at matching sailors to assignments under the AIP program. However, it was shown that the sailor-optimal mechanism resulted in significantly more economic surplus accruing to sailors than by the billet-optimal mechanism. However, the efficiency of the matching mechanisms depends on sailor using a bidding strategy that truthfully represents their WTAs. The experiment is designed to measure the impact of various parameters on bidding strategies.

The program allows matching method, level of WTP information provided to subjects, and level of competition for jobs to be changed. Additionally, communication may or may not be restricted during experiment sessions. A trial run of the experiment showed the program made matches efficiently and effectively as simulation of the proposed matching mechanisms. Minor problems were identified during the trial that will need to be corrected prior to conducting further experiments.

The trial run of the program suggests that bidding will not match WTA, affecting the efficiency of the models. Further testing should be conducted to analyze the factors affecting bidding strategy, and the effect of bidding strategies themselves on efficiency of the matching mechanisms.

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V. SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

A. SUMMARY

This research focused on matching mechanisms proposed by Homb (2006) and Tan (2006) that may be applicable to the Navy's AIP program. Efficient market theory stipulates that efficient distribution of resources requires accurate and open valuations of worth by both buyer and supplier. Commodity or active markets establish efficient prices through multiple transactions. Auctions are an effective means to establish efficient prices where limited transaction opportunities exist. Multiple items may be auctioned sequentially or concurrently. Matching mechanisms are required when multiple items are auctioned at the same time and both buyer and sellers have preferences over the characteristics of the other party.

The Navy's AIP program is an implementation of auction and matching theory. Sailors bid a minimum WTA AIP value. The Navy matches sailors to AIP billets by considering the sailor's bids and the sailor's attractiveness to the billet (e.g., qualifications, transfer and training expenses). Overall effectiveness of the matching process depends on truthful bidding by sailors and valuing of those sailors by the Navy, however both theoretical and experimental evidence suggests that sailors are probably significantly inflating their bids under the current AIP system. Proposed alternative matching mechanisms may provide different truth revealing incentives, and provide more of the economic surplus gained from the matches to either the sailor or the Navy. The sailor-optimal model is expected to be more truth revealing for sailors than the billet-optimal model, however the sailor-optimal model is also expected to pay more AIP than the billet-optimal model. Tan (2006) proposed that the more truth revealing nature of the sailor-optimal model would make it more cost effective than the billet-optimal model.

The experiment program was developed to test how understanding the two matching models would affect a subject's propensity to truthfully reveal their WTA. Experiment subjects competed for generic jobs, emulating negotiating for future assignments. The experiment subjects were given their WTA for each job and limited knowledge of a job's WTP for them, emulating a sailor's preference for those future assignments and what that sailor knows of the other sailors available for that assignment. WTAs and WTPs for jobs ranged from a minimum to maximum total salary. Sailors were modeled as considering total salary since they knew their base pay, and were bidding to add a range of AIPs from zero to a given maximum AIP amount. The generic nature of the experiment should allow extrapolation of experimental results with subjects that are not drawn from the same population as the sailors participating in the AIP program.

The experiment program was tested by simulating a group of ten participants bidding their WTA. Thirty rounds of bidding were completed for both matching models (for a total of 60 rounds of bidding). Effectiveness and efficiency data were calculated and compared to the simulation of the matching models to demonstrate the program's ability to make matches using both models. A trial was conducted with volunteers to test the actual online operation of the program, verify usability of the user interface, and verify the adequacy of the experiment instructions. One minor problem with the program was identified that should be corrected prior to further testing.

Preliminary observations from the trial support the proposal that the sailor-optimal model is more truth revealing than the billet-optimal model. Although there were other factors that decreased the matching rate during the trial, it appears that high bidding also was a factor decreasing the matching rate. It also appeared that surpluses earned by the subjects under the billet-optimal model were correlated with the average difference between WTA and bid amount.

B. CONCLUSIONS

The trial run validates the need to conduct further experiments with this program. Initial observations from the trial run of the experiment suggest that experimental subjects may not bid their WTA values in an attempt to increase their surplus, especially under the billet-optimal model. The only experiment parameter changed during the trial run was the matching model used. The experimental subjects tended to bid higher relative to their WTA value under the billet-optimal model than under the sailor-optimal model.

As expected, the matching rate was lower when subjects did not bid their WTA than when simulations set bids to WTA, indicating the method's efficiency will probably be lower when employed in real world situations.

The experiment design provided similar bidding incentives to experimental subjects as participants in the Navy's AIP program. The experiment assumed that individuals can accurately determine a WTA value. The experiment did not address how individuals determine their WTAs values. The experiment also assumed that the Navy can accurately determine WTP values, and that these values are directly used. Finally, the trial run demonstrated that matches are more likely to be made when bids are lower relative to WTAs. Therefore, matches are more likely at the lower portion of the WTP range. It can be inferred that match rates will be lower if the lower and upper values for WTA are higher than the lower and upper values for WTP. Since the Navy is using AIP to make assignments to billets that are, in general, less desirable, the lower and upper values for WTAs should be higher than those values for WTP, impacting the efficiency of the matching mechanisms.

The experimental program was found to accurately implement the two proposed matching mechanisms. Similar to previous simulations, the experimental program successfully matched over 95% of participants to jobs when bids are equal to WTA. Observed differences between the trial with volunteers and simulations suggest that further testing with live experimental subjects will yield significantly different results than simulations. The setup of the experimental program should provide experiment subjects similar incentives to adjust their bidding strategy as sailors participating in the AIP program.

C. RECOMMENDATIONS FOR FURTHER RESEARCH

A full range of experiments should be conducted to determine the effect factors such as matching mechanism, fidelity of WTP information, level of competition for jobs, and communication during the experiment may have upon the truthfulness of bidding. The costs of the various factors potentially affecting bidding strategy may then be compared to the expected gains from more truthful bidding. Additional experimentation may also be conducted where the lower and upper values for WTA that are different than those for WTP to better emulate the lower desirability of the jobs.

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APPENDIX A. INSTRUCTIONS TO PARTICIPANTS

Slide 1

Good morning/afternoon. I am ________________ with ________________. You are participating in a labor market experiment. The experiment is internet based. Please log on to your NPS account now.

Slide 2

Since this is an economic experiment, we must ensure that each group participating get the same instructions. I will be reading from a script. Please hold your questions until the end of the brief. As you can see, we have a lengthy set of instructions to go through. After administrative remarks about your participation, and an overview I will give you detailed descriptions of the data that you will use in your decisions, and how the program will use your decisions. Finally I'll describe the computer interface.

Slide 3

As a reminder, your participation in this experiment is voluntary. Your participation has no impact on any of your course grades, nor will it affect your fitness reports or evaluations.

You may choose to leave at any time. Should you choose to leave prior to the completion of today's experiment you will still have earned $5 for participating. You can expect to earn, on average, $25 for participating in all 20 bidding sessions today.

Slide 4

You are participating in a labor market experiment in which prospective managers are matched with prospective employers. The amount you earn during this experiment will depend on the decisions that you make as well as the decisions of the other participants. You will each be paid the total amount of your earnings in cash at the end of the experiment. The average earnings in this experiment is expected to be $25, but may vary from as low as $15 to as high as $35. The entire experiment will be conducted on the internet. You will be entering numeric values to indicate your decisions. Please do not talk or otherwise communicate with each other during the experiment. If you have not done so already, please log onto your NPS account. I will give you the website we will use at the end of this instruction period.

Slide 5

In this experiment, you will be simulating the role of a manager seeking employment. The 20 participants in this room have been divided into two groups of 10 managers. The 10 managers in each group are considering employment at ten companies, each of which has a single job opening for which all 10 managers are qualified. There will be twenty sessions where you will bid for these jobs. Each session will be independent of the others.

Slide 6

In each session, managers , you, may be matched to at most one company. Each company can hire at most one manager. Matches will be made partially based on your inputs during the bidding sessions and the inputs of the other participants.

Slide 7

For each of the 10 job openings, there is a minimum salary you are willing to accept, based on factors such as location preference, perceived cost of living, and anticipated job satisfaction. Your minimum acceptable salary for a job opening will be referred to as your "willingness-to-accept", or WTA, for that job. WTAs are given to you. Each manager has different preferences and perceptions, and therefore the managers in your group of 10 will have different values for their willingness-to-accept for any particular job. These values are all randomly generated. Each manager has a WTA for each job, making 10 WTAs for each manager. For all 10 managers that means 100 different random values per bidding session.

Slide 8

Each manager also has different education and experience that makes them more or less valuable to the 10 potential employers. Each employer will also pay the relocation expenses for whichever manager (if any) that is hired. These factors combine to make a maximum salary each employer is willing to pay any particular manager. The maximum salary an employer is willing to pay a particular manager will be referred to as that employer's "willingness-to-pay", or WTP, for that manager. Each employer has different preferences and needs, and therefore the 10 potential employers will have different values for their willingness-to-pay for any particular manager.

Slide 9

You, of course, will not have complete information on how much the company is willing to pay you. However, you will have some idea of how well your qualifications and transfer expenses compare to the other managers in your group for each company. Your WTP ranking tells you your standing among the other managers for that job. For each job, managers are ordered according to their WTP values. The highest three values are in the Top, lowest 4 values in the bottom, and the others in the middle.

Slide 10

As a recap, WTA is the minimum salary you would be willing to accept to work for a company. If you were paid less than that, you project you would be loosing money working for that company, or feel that you're not paid enough for the job. At or above that amount you expect you would be making enough to cover your living expenses, and may be paid more than you need to be to do that job. You would be said to be receiving an economic surplus, which is what your earnings at the end of the experiment will be based on.

WTP on the other hand is the economic benefit the company expects you to generate if they hire you. The company will not hire you if the salary they would have to pay you is higher than WTP.

Both WTA and WTP are generated randomly by the computer each session. WTA and WTP are independent of each other, but are drawn from the same range of possible salaries, from 40 to 80 thousand. Each randomly generated WTA and WTP will be in that range, but there is no guarantee that WTA will be above WTP for every manager and job combination.

Each manager, that is each of you participating in this experiment, will have 10 random WTAs and 10 random WTPs, one each for each company. Each of you will have these WTAs and WTPs generated randomly. Most likely you will all have different values assigned.

Slide 11

The experiment will be broken into 20 bidding sessions, At the start of each session, you will be shown your willingness to accept for each of the 10 job openings, and given a ranking for each employer's willingness to pay amounts for you.

You indicate the minimum salary you would be willing to accept to your potential employers. You may bid to work for as many of the companies as you wish in each period. You will be selected by no more than one company per session.

Slide 12

Each company may receive bids from more than one manager, but may only offer the job to one manager per round. Matching will be made by the computer using one of two methods described later in each period of bidding. In no case will any candidate be matched to a job at less then their bid, nor will a job be matched to a candidate above its willingness to pay.

Slide 13

One of two methods will be used. In both methods the computer will choose a random order to sort through managers and jobs each round. Jobs will only be matched to participants which have bid on them. Each method generates offers based on bids and WTP. The program attempts to match the greatest differences between WTP and bids. Where multiple managers have the same differences between WTP and bid, the program finds the best match by changing the salary to be offered until only one manager has the largest difference.

Slide 14

In the first matching method we will use today, salaries are set to WTP for each manager/job combination. Any job that has a salary set lower than the manager's bid amount will not be considered further. The program cycles through all the managers in a random order to make matches.

Slide 15

The first manager considered will be matched to the job giving him or her the highest non-negative difference between salary and bid. Once a match is made, the potential salaries for all other managers for the job matched to manager 1 are decreased by 1000, indicating competition for that job. The next manager is matched in the same way. If the job matched had already been matched to another manager, that previously matched manager is bumped from the match. Again, salaries for other managers on this job are decreased.

Slide 16

The process continues until all 10 managers are matched without bumping, or no further matches can be made because all the remaining salaries are below bid amount.

Again, at most, one manager will be matched per job.

Slide 17

It is a confusing procedure. Here is an example, using only 3 managers and jobs. WTAs and WTPs are 1 to 7 in this example.

Slide 18

These are randomly generated WTAs for 3 managers and 3 jobs. You will be shown your WTA for each job. You will not be shown anyone else's values. You will also be shown your WTP ranking

Slide 19

Here you can see how ranking relates to actual WTP values. Notice that they are evaluated by Job. For example, Job 1 has values 5, 4, and 6 for managers 1, 2, and 3. They are assigned middle, bottom and top rankings respectively.

Slide 20

Given WTA and WTP ranking, managers make their bids, seen here in green.

Slide 21

Method one starts out by setting potential salaries equal to WTPs.

Slide 22

The sort order for managers and jobs will be different each session. We'll sort through manager in order in this example. So, for the first manager, the potential salaries and bids are compared. In this case the largest difference is for Job one. Manager 1 is then matched to job 1, at an offer of 5. Potential salaries of job 1 to managers 2 and 3 are reduced. Job 3 was an impossible match since the potential salary is less than the bid.

Slide 23

The next manager is compared. Not that the potential salary for manager 2 for job 1 has been decreased since the initial values. In this case it didn't matter, as manager 2 is matched to job 2 regardless.

Slide 24

Next, manager 3 is compared. Note that the Potential salaries for job 1 and 2 have been decreased. Job 2 is an impossible match because the potential salary is less than the bid amount. Job 1 and 3 differences are the same, so the first job in the random sorting will be matched to manager 3. This job had previously been matched to manager 1, so manager 1 is bumped from this job and will be matched again. Potential salaries for job 1 to managers 2 and 3 are decreased.

Slide 25

Since manager 1 was bumped, comparison need to be done again. Again, job 1 is the best match, bumping manager 3. Again, salaries on Job 1 for managers 2 & 3 are decreased.

Slide 26

Manager 2 is skipped since he was not bumped from previous match

Slide 27

Manager 3 is compared again. This time the best match, job 3, which does not bump either of the other 2 managers. At this point matching is complete and you will be able to review the results of that session.

Slide 28

Remember, your take home winnings are based on the choices you and the other participants make. Each $10,000 surplus in the game equates to $1 take home pay. Surplus is calculated by your WTA from the matched salary. On average we expect the participants to average $10,000 surplus each period.

Slide 29

In the initial bidding rounds you will have 5 minutes to complete your bids to allow you time to get familiar with the bidding interface. Later periods will move faster as familiarity increases. You will know when bidding will close.

You may bid on all, some or none of the companies each period.

We should complete 20 sessions.

Slide 30

The computer interface.

Slide 31

In a few moments I'll ask you to start internet explorer and go to the website. You have your logon information at your computer. Once you've logged on, this is the screen you'll see.

<click>

When we are all ready, I'll open the bidding session. At that time click on Bid Jobs

Slide 32

This is the screen where you will enter your bids.

Slide 33

Use the mouse or tab key to navigate among the entry boxes. Be careful making entries.

Slide 34

Once you've bid on all the jobs you wish to bid on, press the submit bids button. Remember, you may bid on all 10 companies, some of the companies, or none of the companies. You have no chance to be matched to jobs to which you've made no bid.

Slide 35

After you've submitted your bids you will come to this screen.

Slide 36

You may change any of your bids.

Slide 37

Simply enter the new value and

<click>

Press change bids button

Slide 38

Deleting a bid is a bit more complicated. You do not just want to just change the value to zero, as that will be recognized as a bid. Rather press the clear button next to the bid you want to remove and

<click>

Press OK on the warning pop-up box.

Slide 39

Notice that the bid will be clear.

<click>

Press the change bids button.

Slide 40

Properly cleared bids will no longer have a clear button next to them.

I will tell you when the bidding session is over. I will ask you if you are finished making bids prior to ending bidding sessions in less than 5 minutes.

<click>

Once the bidding session is over, I'll ask you to click Bid Jobs.

Slide 41

You'll come back to the blank screen again. From here you may click Latest bid info to see your last match and current earnings.

Slide 42

This is also the screen that we'll ask you to print at the end of today's experiment so we can pay you.

Slide 43

Summarizing WTA, WTP, bids and offers. You are given WTA and a WTP ranking.

You input your bids.

The computer considers only Bid and WTP when making matches.

The program generates salaries for matches made.

Your earnings are salaries matched less the WTA amount.

Slide 44

Final points

-At most, one to one matching

-Managers could end up without a match (resulting in no change to running surplus)

The matched salary will not be less than your bid for that job, and not more than the job's WTP.

Slide 45

Questions?

Slide 46

First 10 rounds. Please open internet explorer and navigate to www.forum977.com/auction.

Slide 47

Now that we have completed the first 10 rounds I will describe the matching method for the next 10 rounds.

Slide 48

We will now start using the second matching mechanism. Most of the method is the same: still being done by the program when we close bidding, still based on your inputs and WTP, and the salary won't be less than bid nor greater than WTP

Slide 49

Still limits consideration to managers making bids, and still attempts to maximize WTP/bid difference.

What is different is how potential salary is set, and that the sorting is done by job rather than manager.

Slide 50

In this method, potential salaries are set to the bids (where previously they had been set to WTP).

Slide 51

In this method, the computer cycles through jobs rather than managers to make matches. Matches are made for the largest WTP / potential salary difference. The first company will be matched to the manager with the largest WTP / potential salary difference. Potential salaries for that manager for all other jobs are increased, indicating competition for that manager. Then the next job is considered, and matched similarly. As before, new matches always bump old matches. The same process continues on through all the jobs.

Slide 52

As before, the cycle continue until all 10 jobs are matched, or no further matching can be made because potential salaries are above bid amount.

Slide 53

Again, I will demonstrate using a simple matching example with 3 managers and 3 jobs.

Slide 54

Here's a similar example as we did for the previous method. This is the information you would have.

Slide 55

Here are the underlying values for WTPs

Slide 56

And again, bids are in green.

Slide 57

In this method, Potential salaries are set to bid amount. This is different than the last method where salaries were set to WTP.

Slide 58

Jobs and managers are sorted randomly. Method 2 evaluates jobs one at a time. The first job in this case would be matched to Manager 3. All other potential salaries to manager 3 would be increased.

Slide 59

The second job would be matched to manager 2. Note that the potential salary for manager 3 had been increased, and that that match was impossible since the offer was larger than WTP.

Slide 60

Job 3 has only one possible match. Matching job 3 to manager 3 bumps job 1 match to manager 3.

Slide 61

Back to job 1, two managers have the same high difference. The tie goes to the first manager, which will be randomly determined. This match does not bump any of the other matches, so the cycle is complete.

Slide 62

You can see that in both cases the same jobs are matched to the same managers. This is not always the case. Salaries for method 2 tend to be lower.

The first method we used started the salaries at the max willingness to pay and decreased them due to competition. The method for the remainder of the bidding sessions will have salaries start at your bid, and increase them due to competition.

Slide 63

Questions?

Slide 64

Rounds 11-20.

Labor Market Experiment

Agenda

- Participation and overview
- WTA, WTP, and bidding
- Manager/job matching procedure
- Matching example
- Surplus and earnings
- The computer interface
- Summary

2

Participation

- Your participation in this experiment is strictly voluntary
- Course grades, FITREPs, and evals are unaffected by your participation
- You may leave at any time
  - If you leave before completion of today's experiment you will be paid $5
  - Those who stay until the end of the experiment should earn an average of $25

3

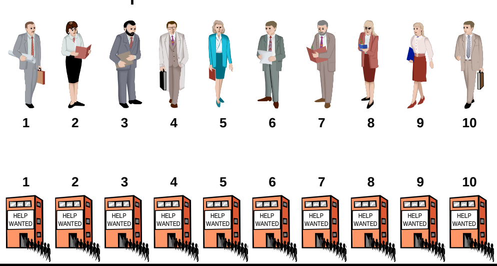
Overview

- Labor market experiment
  - Prospective managers (you) matched with
  - Prospective employers (computer)
- You are seeking employment
- Amount you earn today will be based on decisions you and other participants make
  - Average earnings = $25
- $10,000 game money = $1 real money

4

Participant Breakout

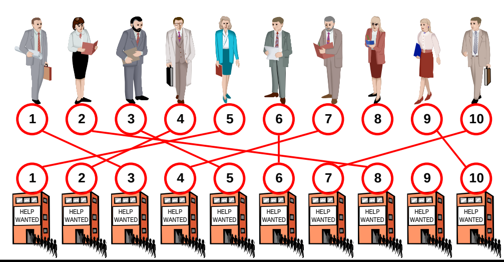
- 20 participants, broken into 2 groups of 10
- Each group seeks employment with its set of 10 companies



5

Matching Managers to Employers

- Each manager matched to one company (or none)
- Each company matched to one manager (or none)
- Matches based on input from you and companies



6

Willingness to Accept (WTA)

- Minimum salary a manager is willing to accept for a particular job
- Based on many factors, such as:
  - Location preference
  - Perceived cost of living
  - Anticipated job satisfaction
- Combined factors yields Willingness to Accept
- WTA values will be randomly generated for each manager for each job
  - 10 managers × 10 companies = 100 WTA values
- WTA values range from $40,000 to $80,000
  - Each value in range equally likely
  - Rounded to nearest $1000

7

Willingness to Pay (WTP)

- Maximum a company is willing to pay for a particular manager (you)
- Each manager
  - Meets requirements for all 10 companies
  - Has different experience and education
  - Will have different relocation expenses
- Companies have different preferences
- Combined factors yield Willingness to Pay
- WTP values randomly generated for each job for each manager
  - 10 managers × 10 companies = 100 WTP values
- WTP values range from $40,000 to $80,000
  - Each value in range equally likely
  - Rounded to nearest $1000

8

Job WTP Standing

- You will not be told a company's WTP for your services
- You will, however, have some idea where you stand relative to other managers for each job
- For each job, you will be told your "Job WTP Standing"
  - "Top" = Among top 3 managers in terms of WTP
  - "Middle" = Among middle 3 managers in terms of WTP
  - "Bottom" = Among bottom 4 managers in terms of WTP

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WTA vs. WTP

- **WTA**: Minimum salary a manager (you) is willing to accept for a particular job
- **WTP**: Maximum salary a company (computer) is willing to pay for a particular manager
- WTA and WTP generated independently
  - No correlation between WTA and WTP
  - If a manager has a high (low) WTA for a job, does not mean job has a high (low) WTP for that manager
- Each manager has different WTAs for each job
- Each job has different WTPs for each manager

10

Bidding

- You will participate in 20 bidding sessions
- Each session you will be given:
  - WTA for each job
  - WTP standing for each job
- You make salary bids to companies
- You may bid on all, some, or none
- You will be matched to no more than one company

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Matching

- Done by computer at bidding close
- Matching based on bids from managers and WTPs from companies
  - Each manager matched to one company (or none)
  - Each company matched to one manager (or none)
- Salary for each manager/company match will fall somewhere between bid and WTP
  - Manager will be paid at least his bid salary
  - Company will pay at most its WTP salary

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Matching Procedure

- Only managers bidding for a particular job are eligible to be matched to that job
- The matching procedure generates matches based on difference between WTP and bid for all manager/company combinations
  - The greater the difference (WTP - bid), the more likely a particular manager/company match is to occur
- The matching procedure systematically generates salaries based on:
  - WTP and bid values
  - Level of competition among employees for each job

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Matching Procedure

- Potential salary for each manager/job combination is initially set equal to company's WTP for that manager
  - Remember: 10 managers × 10 companies = 100 potential salary values
- Managers are randomly assigned a job selection order from #1 to #10

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Matching Procedure

- Manager #1 is tentatively matched to job that provides biggest potential salary - bid split
  - Potential salary each other manager could receive from Manager #1's chosen job is decreased by $1,000
  - Manager #1's potential salary for that job remains unchanged
- Manager #2 matched the same way
  - Potential salary each other manager could receive from Manager #2's chosen job is decreased by $1,000
  - Manager #2's potential salary for that job remains unchanged
  - Any previous match to the same job is dropped
- Process is repeated for Managers #3 through #10
- Unless all 10 managers are matched to a job at the end of the cycle, repeat the process starting with Manager #1
  - Potential salaries (possibly reduced) carry-over to next cycle

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Matching Procedure

- Cycle through manager job selection continues until each manager is matched to a job that provides him/her the largest salary - bid split
  - Given <u>current</u> potential salaries, which likely have been reduced incrementally throughout process
  - Could mean that manager remains unmatched, because all current potential salaries are at or below his/her bids for those jobs
- Each manager will be matched to at most one company they bid on
- Each company will be matched to at most one manager who submitted a bid

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Matching Example
(3 managers & 3 jobs)

Manager Information

Manager	WTA			WTP Standing			Bid		
	Job 1	Job 2	Job 3	Job 1	Job 2	Job 3	Job 1	Job 2	Job 3
1	2	1	6	M	B	M			
2	2	2	2	B	T	B			
3	3	6	5	T	M	T			

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Underlying WTP Values

Manager	WTA			WTP Standing			Bid		
	Job 1	Job 2	Job 3	Job 1	Job 2	Job 3	Job 1	Job 2	Job 3
1	2	1	6	M (5)	B (3)	M (5)			
2	2	2	2	B (4)	T (5)	B (2)			
3	3	6	5	T (6)	M (4)	T (7)			

Manager Bids

Manager	WTA			WTP Standing			Bid		
	Job 1	Job 2	Job 3	Job 1	Job 2	Job 3	Job 1	Job 2	Job 3
1	2	1	6	M (5)	B (3)	M (5)	3	2	7
2	2	2	2	B (4)	T (5)	B (2)	2	2	2
3	3	6	5	T (6)	M (4)	T (7)	3	5	5

Initial Salaries

The matching procedure uses only WTPs and bids

Salaries initially set equal to ***WTPs***

Manager	WTP			Bid			Salary		
	Job 1	Job 2	Job 3	Job 1	Job 2	Job 3	Job 1	Job 2	Job 3
1	5	3	5	3	2	7	5	3	5
2	4	5	2	2	2	2	4	5	2
3	6	4	7	3	5	5	6	4	7

Manager 1 - Cycle 1

Job	Salary	Bid	Salary - Bid
1	5	3	2
2	3	2	1
3	5	7	-

- Tentatively matched to job 1
- Potential salaries for other managers at job 1 decreased by 1

Manager 2 - Cycle 1

Job	Salary	Bid	Salary - Bid
1	3 (orig. 4)	2	1
2	5	2	3
3	2	2	0

- Tentatively matched to job 2
- Potential salaries for other managers at job 2 decreased by 1

Manager 3 - Cycle 1

Job	Salary	Bid	Salary - Bid
1	5 (orig. 6)	3	2
2	3 (orig. 4)	5	-
3	7	5	2

- Two jobs have highest salary - bid split
- Match to first: Job 1
- Bump manager 1 from job 1
- Potential salaries for other managers at job 1 decreased by 1

Manager 1 - Cycle 2

Job	Salary	Bid	Salary - Bid
1	4 (orig. 5)	3	1
2	2 (orig. 3)	2	0
3	5	7	-

- Not all managers matched to jobs at end of cycle, so repeat
- Again, tentatively matched to job 1
- Bump manager 3 from job 1
- Potential salaries for other managers at job 1 decreased by 1

Manager 2 - Cycle 2

Job	Salary	Bid	Salary - Bid
1	1 (orig. 4)	2	2
2	5	2	3
3	5	2	-

- Remains matched to job 2
- If a manager is not bumped from previous match, no choice to make in following cycle
- No change to potential salaries

Manager 3 - Cycle 2

Job	Salary	Bid	Salary - Bid
1	4 (orig. 6)	3	1
2	3 (orig. 4)	5	-
3	7	5	2

- Now matched to job 3
- Potential salaries for other managers at job 3 decreased by 1

- Cycle ends with each manager matched to a job
- Matching process complete

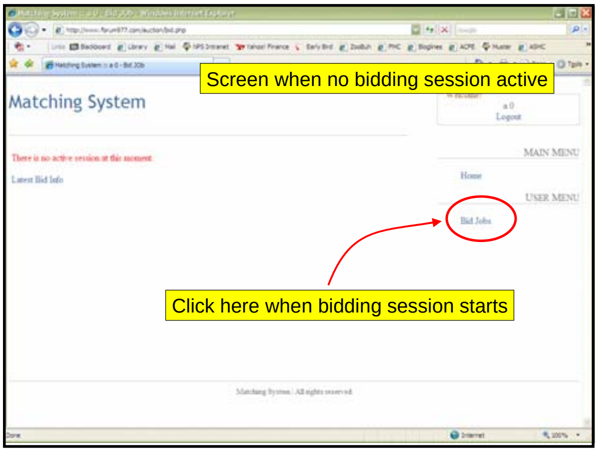
Your Surplus and Earnings

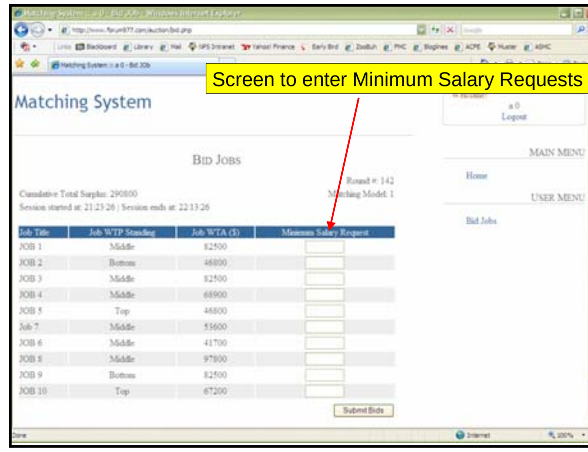
- Experimental earnings based on total surplus from all periods
  - Surplus = Salary - WTA
- Experimental earnings will be converted to actual earnings using exchange rate
  - $10,000 game = $1 take home
- Average earnings expected to be about $25
  - $5 flat payment for participation
  - Average of about $20 depending on decisions made

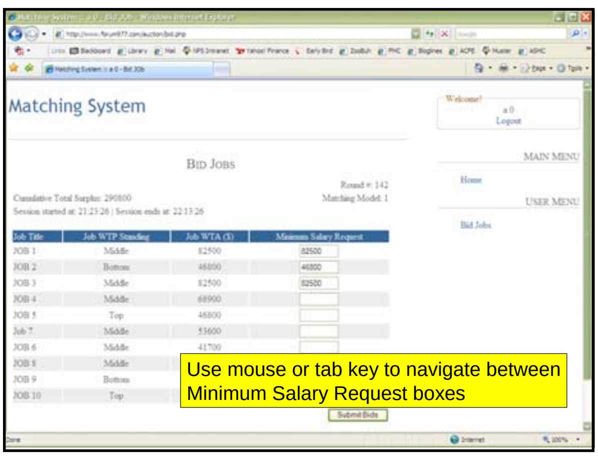
Bidding Periods

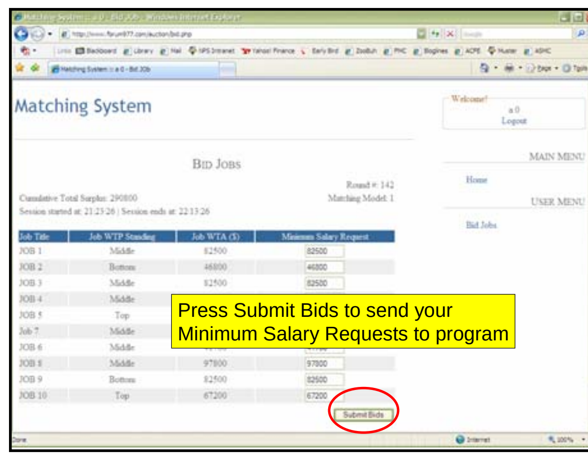
- Expect to participate in 20 periods
- Bidding periods initially 5 minutes
  - Reduced time as familiarity improves
  - You will know time bidding closes
- Place as many bids as you like each period
- You will know your running surplus and your previous matches

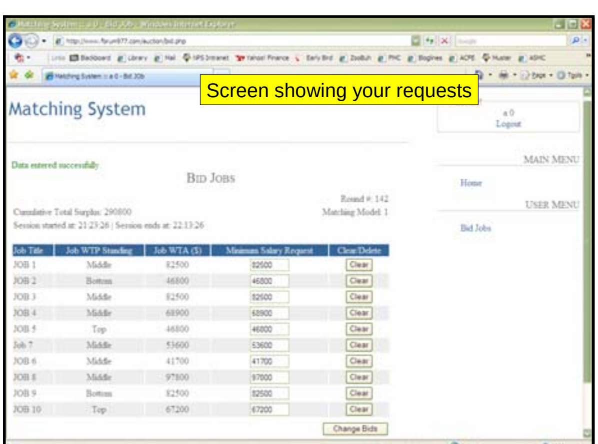
The Computer Interface

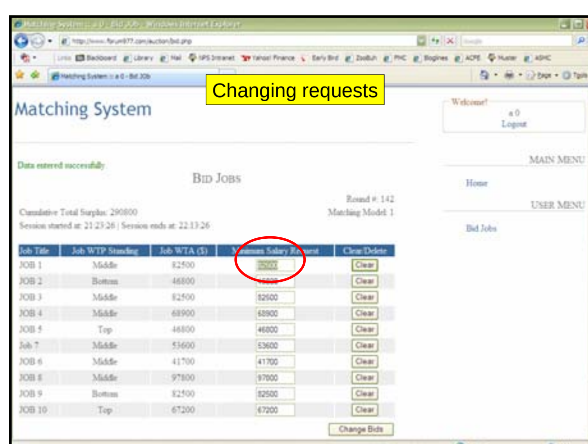

Screen when no bidding session active
Matching System
There is no active session at this moment
Latest Bid Info
MAIN MENU
Home
USER MENU
Bid Jobs
Click here when bidding session starts

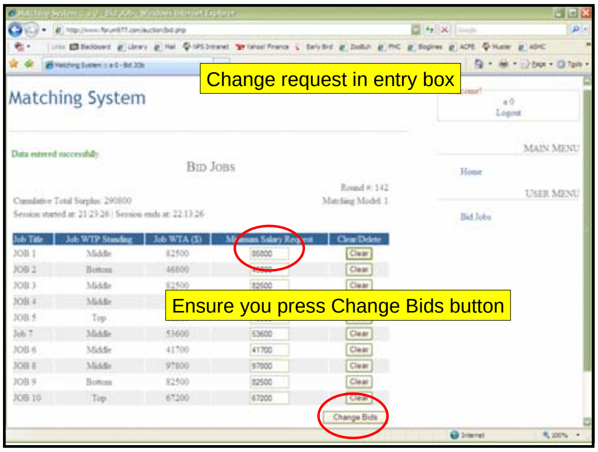

Screen to enter Minimum Salary Requests
Matching System
Bid Jobs
Submit Bids

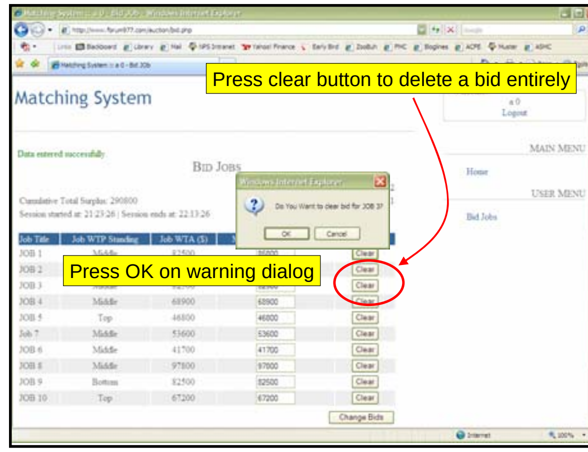

Matching System
Bid Jobs
Use mouse or tab key to navigate between Minimum Salary Request boxes
Submit Bids

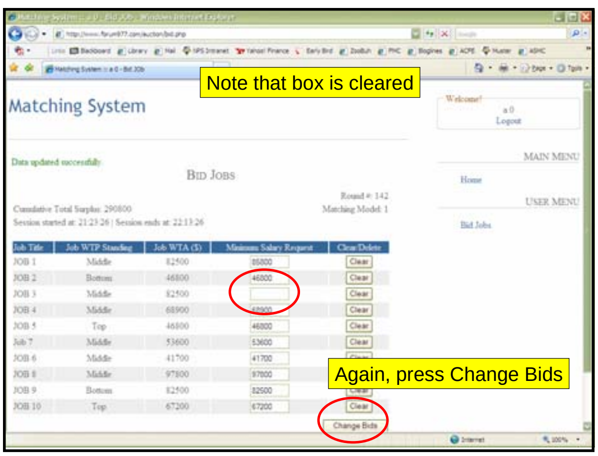

Matching System
Bid Jobs
Press Submit Bids to send your Minimum Salary Requests to program
Submit Bids

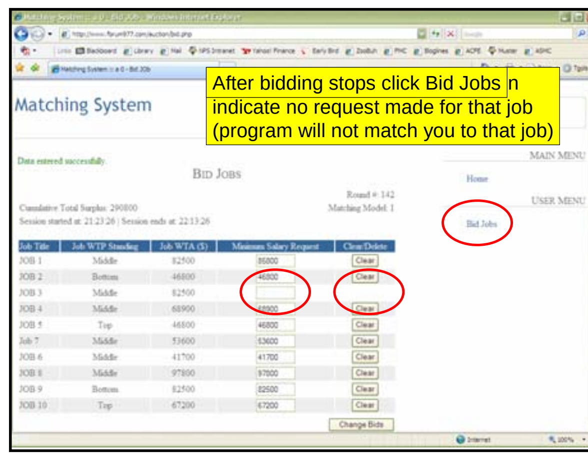

Screen showing your requests
Matching System
Bid Jobs
Change Bids

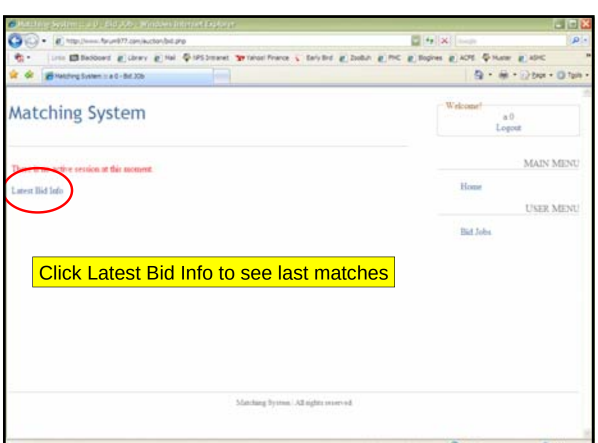

Changing requests
Matching System
Bid Jobs
Change Bids

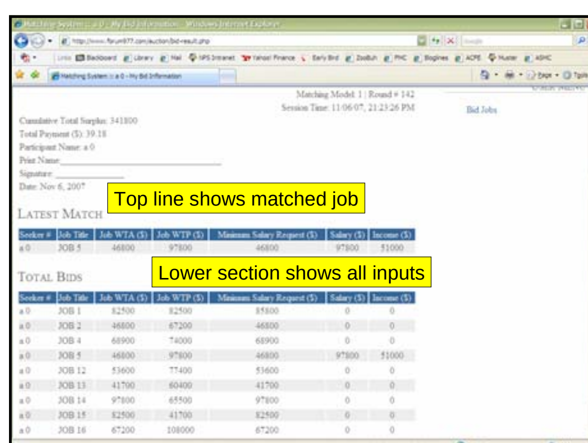

Matching System
Change request in entry box
Ensure you press Change Bids button
Bid Jobs
Change Bids


Matching System
Press clear button to delete a bid entirely
Press OK on warning dialog
Bid Jobs
Change Bids


Matching System
Note that box is cleared
Again, press Change Bids
Bid Jobs
Change Bids


Matching System
After bidding stops click Bid Jobs
indicate no request made for that job
(program will not match you to that job)
Bid Jobs
Change Bids


Matching System
Latest Bid Info
Click Latest Bid Info to see last matches


Top line shows matched job
Latest Match
Total Bids
Lower section shows all inputs

WTA, WTP, Bids, & Salaries

	How generated?	Used in matching?	Determine earnings?
WTA Values	Random draw by computer	No	Yes (Salary - WTA)
WTP Values	Random draw by computer	Yes	No
Bid Values	Participant input	Yes	No
Salary Values	Matching procedure	N/A	Yes (Salary - WTA)

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Key Points

- Matched to one at the most
  - Each managers to at most one job
  - Each job to at most one manager
  - Could be matched to none (unmatched)
- Matching based on WTP & bids (not WTA)
  - Salary will always be at or below WTP
  - Salary will always be at or above bid
- Earnings each round = Salary - WTA

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Questions?

Rounds 1 - 10

- Open Internet Explorer
- Navigate to

  www.forum977.com/auction

- Your username and password is the number at your terminal

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Additional Instructions After First 10 Rounds

New Matching Procedure

- SAME: Done by computer at bidding close
- SAME: Matching based on bids from managers and WTPs from companies
  - Each manager matched to one company (or none)
  - Each company matched to one manager (or none)
- SAME: Salary for each manager/company match will fall somewhere between bid and WTP
  - Manager will be paid at least his bid salary
  - Company will pay at most its WTP salary

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New Matching Procedure

- SAME: Only managers bidding for a particular job are eligible to be matched to that job
- SAME: The matching procedure generates matches based on difference between WTP and bid for all manager/company combinations
  - The greater the difference (WTP - bid), the more likely a particular manager/company match is to occur
- NEW: The matching procedure systematically generates salaries based on:
  - WTP and bid values
  - Level of competition among jobs for each employee

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New Matching Procedure

- NEW: Potential salary for each manager/job combination is initially set equal to manager's bid for that job
  - Remember: 10 managers × 10 companies = 100 potential salary values
- NEW: Companies are randomly assigned a manager selection order from #1 to #10

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New Matching Procedure

- Company #1 is tentatively matched to manager that provides biggest potential WTP - salary split
  - Potential salary each other company must pay company #1's chosen manager is increased by $1,000
  - Company #1's salary for that manager remains unchanged
- Company #2 matched the same way
  - Potential salary each other company must pay company #2's chosen manager is increased by $1,000
  - Company #2's salary for that manager remains unchanged
  - Any previous match to the same job is dropped
- Process is repeated for companies #3 through #10
- Unless all 10 companies are matched to a manager at the end of the cycle, repeat the process starting with company #1
  - Potential salaries (possibly increased) carry-over to next cycle

51

New Matching Procedure

- Cycle through company manager selection continues until each company is matched to a manager that provides it the largest WTP - salary split
  - Given current potential salaries, which likely have been increased incrementally throughout process
  - Could mean that company remains unmatched, because all current potential salaries are at or above its WTPs for those managers
- Each manager will be matched to at most one company they bid on
- Each company will be matched to at most one manager who submitted a bid

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Matching Example
(3 managers & 3 jobs)

Manager Information

Same WTA & WTP values used in original example

Manager	WTA			WTP Standing			Bid		
	Job 1	Job 2	Job 3	Job 1	Job 2	Job 3	Job 1	Job 2	Job 3
1	2	1	6	M	B	M			
2	2	2	2	B	T	B			
3	3	6	5	T	M	T			

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Underlying WTP Values

Same WTA & WTP values used in original example

Manager	WTA			WTP Standing			Bid		
	Job 1	Job 2	Job 3	Job 1	Job 2	Job 3	Job 1	Job 2	Job 3
1	2	1	6	M (5)	B (3)	M (5)			
2	2	2	2	B (4)	T (5)	B (2)			
3	3	6	5	T (6)	M (4)	T (7)			

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Manager Bids

Same bid values used in original example

Manager	WTA			WTP Standing			Bid		
	Job 1	Job 2	Job 3	Job 1	Job 2	Job 3	Job 1	Job 2	Job 3
1	2	1	6	M (5)	B (3)	M (5)	3	2	7
2	2	2	2	B (4)	T (5)	B (2)	2	2	2
3	3	6	5	T (6)	M (4)	T (7)	3	5	5

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Initial Salaries

New matching procedure <u>also</u> uses only WTPs and bids

Salaries initially set equal to ***bids***

Manager	WTP			Bid			Salary		
	Job 1	Job 2	Job 3	Job 1	Job 2	Job 3	Job 1	Job 2	Job 3
1	5	3	5	3	2	7	3	2	7
2	4	5	2	2	2	2	2	2	2
3	6	4	7	3	5	5	3	5	5

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Job 1 - Cycle 1

Mgr	WTP	Salary	WTP - Salary
1	5	3	2
2	4	2	2
3	6	3	3

- Best WTP - Salary split provided by manager 3
- Tentatively matched to manager 3
- Salaries other jobs must pay manager 3 increased by 1

Method 2

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Job 2 - Cycle 1

Mgr	WTP	Salary	WTP - Salary
1	3	2	1
2	5	2	3
3	4	6 (orig. 5)	-

- Tentatively matched to manager 2
- Salaries other jobs must pay manager 2 increased by 1

Method 2

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Job 3 - Cycle 1

Mgr	WTP	Salary	WTP - Salary
1	5	7	-
2	2	3 (orig. 2)	-
3	7	6 (orig. 5)	1

- Tentatively matched to manager 3
- Bump job 1 from manager 3 match
- Salaries other jobs must pay manager 3 increased by 1

Method 2

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Job 1 - Cycle 2

Mgr	WTP	Salary	WTP - Salary
1	5	3	2
2	4	3 (orig. 2)	1
3	6	4 (orig. 3)	2

- Two managers provide highest WTP - salary split
- Match to first: Manager 1
- Salaries other jobs must pay manager 1 increase by 1

- Jobs 2 and 3 remain with previous matches
- Matching process complete

Method 2

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Matching Procedure Comparison

Manager	Procedure 1		Procedure 2	
	Job	Salary	Job	Salary
1	1	4	1	3
2	2	5	2	2
3	3	7	3	6

- Two procedures will often (but not always) generate same manager/job matches (given same WTPs & bids)
  - Method 1: Matches based on salary - bid splits, but salary initially = WTP, so initial matches based on WTP - bid splits
  - Method 2: Matches based on WTP - salary splits, but salary initially = bid, so initial matches also based on WTP - bid splits

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Questions?

Rounds 11-20

- If your session times out use the same logon (previous data are saved)

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APPENDIX B. WEBSITE USER GUIDE

A. WEBSITE INTRODUCTION

The experiment uses code hosted at http://www.forum977.com/auction/. The interface is dynamically generated webpages using PHP scripting language and the mySQL database engine. It was developed to work with all web browsers, but has only been tested with Microsoft Internet Explorer 7.0. The site is password protected. Accounts have either administrative or general user access.

General users may bid for jobs when bidding sessions are started by administrator users. Users bid are grouped, and are given information pertaining to their group, and compete only with their group for jobs. When the bidding session is closed, users who submitted bids are matched to jobs, and given salaries and surpluses.

B. ADMINISTRATIVE CONTROL

Administrative users can add, delete, or modify user accounts, available jobs, WTA and WTP ranges, start and stop bidding sessions, and view previous sessions (see Figure 4.).

Figure 4. Administrative Menu

1. User Control

All users must have an account established through the “Add User” Admin Menu link. Users must be given a first and last name. This first and last name will be displayed on all user bid submission and history pages. Users must also be given a unique username, which is used for logging onto the website. Finally, a password must be provided for each user. By default, users are given general access, but may be given administrator access. Administrator accounts can not make bids. The title option is no longer used and may be ignored.

New users are assigned to group 1 by default. User groups may be changed by following the “Change User/Group” Admin Menu link. The program currently can have a maximum of 10 users in groups participating in bidding sessions. User names, passwords, and access level may be changed by following the “All Users” Main Menu link. Users may also be deleted by following this link.

2. Jobs Control

Additional jobs may be added through the “Add Job” Admin Menu link. Jobs may only be given a name (e.g., Job 1). Job names may be edited by following the “All Jobs” Main Menu link. That link also shows whether jobs will be made available for bidding (only jobs with a check mark in the Select/Unselect box are available for bidding). To make a job available for bidding (or remove it from bidding) click the check box, and press the “Select/Unselect” button at the bottom of the page. The maximum number of jobs that may be selected is currently 10. Finally, jobs may be deleted entirely at this link.

3. WTA and WTP Control

Ranges for WTA and WTP are set at the “Add WTA/WTP” Admin Link. Upper and lower bounds for WTA and WTP can be set independently, and are inclusive. The ranges WTA and WTP (i.e., Upper Range – Lower Range) must be divisible by the steps entered for that range. The size of the salary step may also be changed on this page. Prior to starting every bidding session the Update WTA/WTP button must be pressed.

4. Bidding Session Control

Bidding sessions are controlled via the “Manage Bids” Admin Menu link. Maximum duration for bidding sessions may be changed on this page. To start a bidding session first select matching model (Seeker Optimal or Job Optimal) and press the “Start bidding session” button. General users may make bids on available jobs until time expires or the administrator presses the “Stop bidding session” button. The administrator is able to see bids that users make during the bidding session.

5. Viewing History

The WTAs, WTPs, user bids, salaries and matches made (all user/job combinations, not just matched combinations) are saved for each bidding session at the “All Rounds” Main Menu link. The match and salary information from the most recently completed bidding session can be viewed at the “Recent Match” Admin Menu link. All matches and salary information (matched combinations only) can be viewed at the “All Matches” Admin Menu link.

C. GENERAL USER INTERFACE

General users may only bid for jobs (during bidding sessions) view previous match results and see their current surplus. Once an administrator has started a bidding session general users access the bidding page through the “Bid Jobs” User Menu link.

Bidders will be presented their WTA and WTP ranking for each job available for bidding. They will be presented their information only. Bidders may make bids on any or all of the jobs available, navigating between the entry fields by mouse or tab button. When satisfied with their bids, the bidder presses the “Submit Bids” button. The user will then be able to change or delete any of those bids until the bidding session is stopped. Users must press the “Change Bids” button to change their registered bids. Users must use the “Clear” and “Change Bids” buttons to withdraw a bid completely.

At the completion of a bidding session, users should press the “Bid Jobs” User Menu link, and click “Latest Bid info” to see their matched job and salary. This page also shows the running surplus that the user has earned through all the bidding sessions.

D. GENERIC EXPERIMENT FLOW

The following table is a general outline for conducting an experiment with the described program.

<table>
<tr><th colspan="3">Prior to experiment</th></tr>
<tr><td colspan="3">Recruit volunteers</td></tr>
<tr><td colspan="3">Prepare any surveys</td></tr>
<tr><td colspan="3">Obtain payment money</td></tr>
<tr><td colspan="3">Ensure access to sufficient computers with access to the internet</td></tr>
<tr><td colspan="3">Create sufficient new user accounts</td></tr>
<tr><td colspan="3">Assign users to groups</td></tr>
<tr><td colspan="3">Set initial WTA/WTP and step sizes</td></tr>
<tr><td colspan="3">Ensure sufficient jobs are created and selected</td></tr>
<tr><td colspan="3">Ensure bidding session time correct</td></tr>
<tr><th colspan="3">During experiment</th></tr>
<tr><td colspan="3">Assign participants to account</td></tr>
<tr><td colspan="3">Change number of jobs selected if required</td></tr>
<tr><td colspan="3">Change user groups if required</td></tr>
<tr><td colspan="3">Give instructions</td></tr>
<tr><td colspan="3">Direct users to logon to website</td></tr>
<tr><td rowspan="6"></td><td colspan="2">For each session</td></tr>
<tr><td>Admin</td><td>Click “Add WTA/WTP”
Change if required
Always press “Update WTA/WTP”</td></tr>
<tr><td>Admin</td><td>Click “Manage bids”
Select Matching Model
Press “Start Bidding”
Wait until window no longer says session has ended
Direct participants to begin bidding</td></tr>
<tr><td>Participants</td><td>Click “Bid Jobs”
Place bids
Change bids as necessary</td></tr>
<tr><td>Admin</td><td>Allow bidding time to expire or press “Stop bidding” button</td></tr>
<tr><td>Participant</td><td>Click “Bid Jobs”
Click “Latest round info”</td></tr>
<tr><th colspan="3">Completing experiment</th></tr>
<tr><td>Participants</td><td colspan="2">Click latest bid info
Print this page (your receipt to collect money)
Turn in page and other survey sheets
Collect money</td></tr>
<tr><td>Administrator</td><td colspan="2">Pay out</td></tr>
</table>

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